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AFWAL-TR-82-1173

AVIONICS SOFTWARE SUPPORT COST MODEL

SYSCON Corporation
1050 Thomas Jefferson Street
Washington, DC 20007

1 February 1983

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Final Report for Period
September 1980 – November 1982

Approved for public release: distribution unlimited

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AIR FORCE SYSTEMS COMMAND
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Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
AFWAL-TR-82-1173	AD-A128 523	

4. TITLE (and Subtitle)	5. TYPE OF REPORT & PERIOD COVERED
AVIONICS SOFTWARE SUPPORT COST MODEL	Technical Report: Final Sept 1980 - Nov 1982
	6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)	8. CONTRACT OR GRANT NUMBER(s)
	F33615-80-C-1157

9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
SYSCON Corporation 1050 Thomas Jefferson Street Washington, DC 20007	2003-09-15

11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE
Avionics Laboratory (AFWAL, AAAS) AF Wright Aeronautical Laboratories, AFSC Wright-Patterson AFB, OH 45433	1 February 1983
	13. NUMBER OF PAGES
	256

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report)
	Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved For Public Release: Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Avionics	Support Costs
Cost Estimating Relationships	Software Support
Life Cycle Cost	ASSCM
Cost Models	
Software	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the work performed to develop the Avionics Software Support Cost Model (ASSCM). ASSCM is an interactive model which projects annual software support costs of various proposed avionics software configurations during the early design phase of system development. It bases cost projections on a unique algorithm designed to use as much historical data as possible. The algorithm also relies on subjective information obtained from a large group of individuals familiar with support software and its costs.

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PREFACE

The Avionics Software Support Cost Model is a new step forward in an attempt to estimate the cost of maintaining onboard embedded computer software. SYSCON Corporation is pleased to be a part of this effort and to have an opportunity to explore new areas to apply its expertise. SYSCON would like to offer its gratitude to the Air Force for its patience, understanding, and guidance. In particular SYSCON wishes to extend a special thanks to Mr. Dan Ferens, the Avionics Laboratory Project Monitor, for his continuous help in bringing this contract to a successful conclusion.

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SUMMARY

For some time now the Air Force has become acutely aware of the ever escalating costs for maintaining embedded computer software. Such costs are necessary to keep onboard avionics systems completely up-to-date with users' requests. To accomplish this, each software system is currently provided with its own uniquely qualified staff. The sole responsibility for these people is to design, develop, integrate, test, and document the software on a continuing basis. The Air Force is now attempting to better control the costs of providing this vital support function.

By studying the factors which affect the costs of maintaining embedded computer software, the Air Force hopes to develop, support, and computerize a methodology to accurately predict these costs. To accomplish this, SYSCON Corporation has developed the Avionics Software Support Cost Model (ASSCM). The ASSCM is the result of more than two years of work. It is an interactive model that projects annual software support costs for various proposed software configurations during the early design phase of system development. It bases its cost projections on a unique algorithm specifically designed to utilize as much of the available historic data as possible. To complement this data, the algorithm also relies on subjective information obtained from a large group of individuals intimately familiar with software support and its costs.

This final report describes the work effort and provides the information necessary to understand, use, and, perhaps, update the ASSCM.

1 SCOPE

1.1 Purpose

This final report provides the necessary information to support the development, implementation, use, and understanding of the Avionics Software Support Cost Model (ASSCM). This model was designed according to the stipulations and guidelines of the Avionics Laboratory at Wright-Patterson Air Force Base (WPAFB) by SYSCON Corporation under contract number F33615-80-C-1157.

1.2 Functional Summary

The ASSCM is a predictive model which enables the user to estimate the support costs associated with embedded computer software for avionics systems. The model is applicable to a wide variety of avionics computer software; specifically, operational flight program (OFP) software, airborne communications/electronics (CE) software, and airborne electronic warfare (EW) software for these programs. The model does not address software acquisition costs, nor the costs incurred by the users at operational commands for operating the software.

2   APPLICABLE DOCUMENTS

The following list of documents are related to the total work effort and should be used as additional reference material. Several of these documents are referred to in this Final Technical Report and are described as such. In the event of conflict between the documents referenced herein and the contents of this document, the contents of this document shall be considered a superceding requirement.

1. Statement of Work - Avionics Software Support Cost Model (March 26, 1980)

2. Predictive Software Operation and Support Software Cost Model Development - Technical Review/Progress Report (January 23, 1981)

3. Methodology for Estimating Avionic Software O&S Cost-Concept Paper (March 19, 1981)

4. Predictive Software Operation and Support Cost Model Development - Technical Review/Progress Report (March 19, 1981)

5. Comparison Of Employee Benefits In Private, Federal Sectors, Office Personnel Management (July 1, 1981)

6. Predictive Software Operation and Support Cost Model Development - Preliminary Design Review (November 5, 1981)

7. Avionics Software Support Cost Model (ASSCM) - Software Design Specification (March 31, 1982)

8. Predictive Software Operation and Support Cost Model Development - Detailed Design Review (July 14, 1982)

9. Predictive Software Operation and Support Cost Model Development - Final Presentation (October 13, 1982)

10. Predictive Software Operation and Support Cost Model Development - Training Course Material (October 14, 1982)

11. Avionics Software Support Cost Model (ASSCM) - User's Manual (February 1, 1983)

12. Avionics Software Support Cost Model (ASSCM) - Computer Program Product Specification (February 1, 1983)

13. Avionics Software Support Cost Model (ASSCM) - Model Validation (December 1, 1982)

3 OVERVIEW

The ASSCM was developed over a 27 month period from September 1980 through November 1982. During this time a comprehensive effort to understand, evaluate, and project embedded computer software maintenance costs was completed. This effort included the following major milestones:

- Review
- Methodology Development
- Data Collection
- Data Organization and Analysis
- Algorithm Development
- Computerization
- Model Validation
- Documentation

3.1 Review

This task lasted approximately seven months and included a review of all applicable documents and current software maintenance procedures. During th⁻ time, discussions were held on site at various Air Logistic Centers (ALC's) with Air Force personnel.

3.2 Methodology Development

This task concerns the development of the model algorithm to be used by the computer for projecting costs. The methodology that was ultimately used was derived specifically as a result of the review process. It reflects a simulation of real world software maintenance procedures as well as a pragmatic approach designed to compensate for the limited amount of available data.

3.3 Data Collection

As a result of the formulated methodology, a two-phased data collection effort was initiated. Phase I consisted of t   collection of historical data for each system currently past the Program Management Responsibility Transfer (PMRT) date. A Phase I questionnaire was designed to obtain the software support costs expended as well as information about the characteristics associated with the software. A Phase II questionnaire was drawn up to obtain certain subjective information about those characteristics. Because of the limited historic data available, subjective data was provided by Air Force personnel on how changes in certain characteristics affect software support cost incurrence.

3.4 Data Organization and Analysis

The data collected from the field was coded and edited so that it could be analyzed for use by the model. The cost information was normalized to remove individual differences caused by extraneous factors (physical location, command decisions, salary steps, inflation etc.). The characteristics information was simply edited for completeness and summarized. Finally, the subjective information was inputted into a computer. Using a statistical package, arithimetic equations and functions were derived which reflect the trends in the answers provided by the respondents.

3.5 Algorithm Development

An algorithm utilizing the information collected was established to project software maintenance costs. The algorithm started with the historical costs and characteristics as the baseline data. The costs were then adjusted according to the characteristic values of the system described by the model

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user. The adjustments were accommmplished by applying the derived modification factors and functions.

3.6 Computerization

The model algorithm, normalization factors, modification factors, and other necessary information was programmed into a computer. The computer automated the process by which the user may offer his own support software characteristics and facilitated the thousands of computations necessary to complete the cost projection methodology.

3.7 Model Validation

The model was validated by inputting the characteristics of three existing systems whose costs were not used in the model development. The costs projections were compared with the actual costs and the major discrepancies were examined and explained.

3.8 Documentation

All of the information required to develop, implement, and use the ASSCM belongs to the Air Force. An audit trail to support all of the data utilized by the model, as well as the algorithm itself, is provided in this document as well as other publications provided to the Air Force. See also the referenced documents in Section 2 .

4 MODEL DEVELOPMENT

4.1 Review

The review period enabled SYSCON personnel to become familiar with how current software maintenance costs are generated, the procedures and problems associated with software maintenance, existing data available, and current methodologies used for estimating these costs. The review consisted of data gathering trips to three ALC's and a comprehensive review of all documents written heretofore related to the subject of projecting costs for maintaining embedded computer software. The three trips were designed to obtain any available data or documents which might by useful and to find out as much as possible about software maintenance costs and the factors which affect those costs. The dates, destination and SYSCON personnel involved are summarized below:

Date	Destination	Systems Discussed	Personnel
9/22/80	China Lake, CA	A-7	J. Cyr
11/3/80-11/7/80	OC-ALC	E-3A	T. Pavlick, J. Murray
1/12/81-1/16/81	SM-ALC	F-111F, F-111D FB-111A	J. Murray, B. Johnson
2/9/81-2/13/81	WR-ALC	APR-38, ALQ-155 ALQ-131, ALR-69 ALR-46, ALR-62	W. Gagner, R. Bentley, J. Murray

The major conclusions that resulted from this review are summarized below:

- The ALC's collect cost data independently, providing a nonstandard means for summarizing information for all ALC's.

- There were too few systems with post-PMRT experience to develop
  statistical cause-and-effect relationships between costs and
  software characteristics.
- Air Force personnel were very interested in estimating software
  support costs but had no formal means for doing so at this time.
- Labor cost data was collected uniformly on Form 75 for all ALC's;
  however, this information was projected (not actual) and could not
  be used to support the ASSCM in its present form.
- Indirect labor costs and support equipment costs are not broken
  out by system, nor are the costs available from one source.
- Where cost information exists for a specific system, summarizing
  it would be an extremely time-consuming and costly effort, perhaps
  reaching a point of diminishing returns.
- There are certain software characteristics which directly impact
  upon software maintenance costs. These include program size,
  language, complexity rating, structure, etc. and are discussed in
  greater detail in section 4.2.
- An algorithm uniquely capable of simulating a situation wherein
  limited available data is required to project software maintenance
  costs would best achieve the Air Force's goals.

SYSCON's conclusions about the lack of available data were not
encouraging insofar as the development of a computer model based on
statistically reliable manipulations of a comprehensive data base. Prior to
suggesting an alternative methodology, SYSCON presented its summary of data
collection problems. This is provided in APPENDIX A.

As a result of these observations and conclusions, SYSCON developed an

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alternative pragmatic approach for estimating support costs of future embedded computer systems. This was presented on March 19, 1981 in a concept paper. (See Applicable Document No. 3)

4.2 Methodology Development

After the data collection trips and the information received was digested, SYSCON developed a unique methodology upon which to base the model. This methodology makes use of the data currently available while providing a means to logically project and support cost estimates.

The first task was to develop a standardized means for collecting cost information. This effort resulted in the work breakdown structure (WBS) shown in FIGURE 1. This WBS enables one to collect cost data for all systems such that a consistent definition of costs can be assured. This formed the basis from which costs were collected and projected, enabling costs for the various systems to be properly and reliably compared.

Associated with the costs collected for supporting the embedded computer software of any one system are the characteristics that describe that system. As a result of the review effort, sixteen factors were hypothesized to affect costs. These factors, as well as some additional descriptive information, are listed in FIGURE 2. Depending upon the value given for each of the characteristics, software support costs could be expected to increase or decrease in a predictable fashion. This forms the basis upon which the methodology is founded.

The general methodology with a specific example was provided to the Air Force in Applicable Document No. 3. It relies on historical information from current systems to constitute the baseline data. It then assumes that relationships between costs and changes in the characteristics that describe

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FIGURE 1
AVIONICS SOFTWARE WORK BREAKDOWN STRUCTURE

TOTAL SUPPORT COST

LABOR
- INDIRECT
  - SUPERVISION
  - ADMINISTRATION
- DIRECT
  - EMBEDDED COMPUTER SOFTWARE
    - REQUIREMENTS
    - REVIEW
    - DESIGN
    - DEVELOPMENT
    - INTEGRATION
    - TEST & EVALUATION
    - DOCUMENTATION
    - REPRODUCTION/INSTALLATION
  - SUPPORT SOFTWARE

SUPPORT EQUIPMENT
- GENERAL
  - FACILITY/UTILITIES
  - FURNISHINGS
  - MATERIAL/SUPPLIES
  - COMPUTER/TERMINALS
  - MAINTENANCE
- DIRECT
  - EMBEDDED COMPUTER SYSTEM/INTERFACES
  - LAB EQUIPMENT
  - SIMULATOR
  - SOFTWARE
  - TEST AIRCRAFT/TIME
  - REPRODUCTION

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FIGURE 2
DESCRIPTIVE SYSTEM CHARACTERISTICS

PARAMETERS	RANGE OF ACCEPTABLE VALUES
APPLICATION TYPE (1-7)	SEVEN TYPES AVAILABLE, SEE NOTE 1
FIRST YEAR OF SUPPORT	1970-2025
LINES OF CODE	1 – 9999 THOUSAND
LANGUAGE (1-3)	ASSEMBLY, FORTRAN, STRUCTURED HOL
% MEMORY FILL	1–100%
% TIMING FILL	1–100%
DEV V&V RATING (1-3)	NONE, DONE BY DEVELOPER, TOTAL IV & V
DESIGN RATING (1-4)	POOR, FAIR, GOOD, EXCELLENT
IMPLEM RATING (1-4)	POOR, FAIR, GOOD, EXCELLENT
INIT DOC RATING (1-3)	NONE, INCOMPLETE/OUTDATED, UP-TO-DATE
REPRODUCTION MEDIUM (1-3)	MYLAR TAPE, PROM, MAG TAPE
AIRCRAFT TYPE (1-4)	CARGO, BOMBER, FIGHTER, SURVEILLANCE
NO. FIELDED SYS	1 – 9999
COMPLEXITY	1 – 5
RATE OF CHANGE	1 – 5
SKILL LEVEL MIX	1 – 5
CHANGE EFFICIENCY	10% – 100%
DIRECT SUPP'T EQUIPMENT	
HARDWARE	1–999.999 ($ MILLION)
YEAR ACQUIRED	1970-2025
SOFTWARE	1–999.999 ($ MILLION)
YEAR ACQUIRED	1970-2025
EXPECTED SYSTEM LIFE	1–99 (YEARS)
BLOCK CHANGE LENGTH	1–99 (MONTHS)
SUPPORT SOFTWARE MAINTENANCE (1, 2)	YES, NO
% OF WORK PERFORMED BY CONTRACTOR	0% – 100%
LOCATION OF CONTRACTORS (1, 2)	ON-SITE, OFF-SITE

NOTE 1: NAVIGATION/WEAPON DELIVERY OFP, JAMMER EW, FIRE CONTROL OFP, RECEIVER EW, INTEGRATED SYSTEM EW, NAVIGATED FIRE CONTROL/WEAPON DELIVERY OFP, COMMAND & CONTROL CE.

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the software can be quantified and applied to the historic costs to form a new, projected cost estimate. Costs are defined according to the WBS and are adjusted according to arithimetic modification equations. The modification equations are to be derived from data collected from Air Force personnel who are intimately familiar with software maintenance.

4.3 Data Collection

To accomplish the data needs to support the methodology, two separate questionnaires were designed. The Phase I questionnaire seeks specific information about a particular system as well as general information which might apply to several systems. FIGURE 3 lists the information requested by the Phase I questionnaire. It should also be noted that the Phase I questionnaire was completed by only one person per system, usually the lead engineer or supervisor. Where the general information is not known, additional personnel (usually administrative) were contacted at the various ALC's. A copy of the Phase I questionnaire is provided in APPENDIX B.

The Phase II questionnaire is designed to obtain subjective information. This questionnaire was to be completed by as many software support engineers as possible. The objective is to find out how changes in certain characteristics affect labor costs and to derive mathematical functions to reflect the overall trend of answers. FIGURE 4 provides the information about which expert judgment was requested. The Phase II questionnaire is provided in APPENDIX C.

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FIGURE 3

PHASE I QUESTIONNAIRE INFORMATION REQUESTED

APPLICATION TYPE

PMRT DATE

CURRENT BLOCK CHANGE NUMBER

YEAR OF SUPPORT

DOCUMENTATION RATING AT PMRT

LENGTH OF BLOCK CHANGE

DEVELOPMENT V&V RATING

TEST AIRCRAFT TYPE

REPRODUCTION MEDIUM

NUMBER OF FIELDED SYSTEMS

EXPECTED SYSTEM LIFE

APPROXIMATE DIRECT HARDWARE COST

YEAR OF ACQUISITION

APPROXIMATE SUPPORT SOFTWARE COST

YEAR OF ACQUISITION

SOFTWARE FLIGHT TEST HOURS

CHANGE HISTORY

EMBEDDED COMPUTER SYSTEM INFORMATION

EMBEDDED COMPUTER SOFTWARE INFORMATION

SOFTWARE STRUCTURE RATINGS

COMPLEXITY RATING

RATE OF CHANGE RATING

SKILL LEVEL MIX RATING

SUPPORT SOFTWARE INFORMATION

DIRECT LABOR MANMONTHS EXPENDED BY PHASE

COST PER MANMONTH BY LEVEL

CONTRACTOR COSTS

INDIRECT LABOR REQUIREMENTS

GENERAL SUPPORT EQUIPMENT REQUIREMENTS

DIRECT SUPPORT EQUIPMENT REQUIREMENTS

FIGURE 4
PHASE II QUESTIONNAIRE INFORMATION REQUESTED

IMPACT ON MANHOURS FROM CHANGING:

LINES OF CODE

LANGUAGE

% MEMORY FILL

% TIMING FILL

% WORK PERFORMED BY CONTRACTORS

DEVELOPMENT V&V RATING

PROGRAM DESIGN STRUCTURE

PROGRAM IMPLEMENTATION STRUCTURE

INITIAL DOCUMENTATION RATING

YEAR OF SUPPORT

AIRCRAFT TYPE

NUMBER OF FIELDED SYSTEMS

COMPLEXITY

RATE OF CHANGE

SKILL LEVEL MIX

CHANGE EFFICIENCY

ATTRIBUTES OF AN AVERAGE SYSTEM

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With questionnaires in hand, additional data collection trips to the
ALC's were made by SYSCON personnel. These are summarized below:

DATE	Destination	Systems Discussed	Personnel
8/17/81-8/19/81	OO-ALC	F-4,F-16	R. Bentley, J. Murray
8/19/81,8/20/81	SM-ALC	F-111F, F-111D FB-111A	R. Bentley, J. Murray
8/21/81	Point Mugu, CA	F-14	R. Bentley, J. Murray
10/12/81,10/13/81	WR-ALC	APR-38,ALQ-155 ALQ-131,ALR-69 ALR-46,ALR-62	R. Bentley, J. Murray
10/13/81,10/14/81	OC-ALC	E-3A, A-7	R. Bentley, J. Murray

4.4 Data Organization and Analysis

Data was collected using the Phase I and Phase II questionnaires from all
known sources where embedded computer software was being maintained. FIGURE 5
summarizes the location, systems, and type of data collected.

As stated above there are two distinct types of data: historical and
subjective. The historical data for each system includes actual costs
expended during the most recent block change period as well as various
descriptive information about the software and the people maintaining the
software. This information was summarized and edited for completeness. The
data for seven systems was deemed sufficiently complete. These systems
eventually became the baseline data for the ASSCM. Data for three other
systems were used to facilitate the model validation.

Phase II data was collected from thirty-nine individuals who were
currently maintaining embedded computer software. These people exhibited
varying degrees of experience and provided a wide spectrum of responses from
which to derive trends. Each of the questionnaires was admininstered by

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FIGURE 5
DATA COLLECTED

ALC	SYSTEM	TYPE	PHASE I	PHASE II	ASSCM USE	
					BASELINE	VALIDATION
00–ALC	F–16 FCC	OFP	X	X	X	
	F–16 FCR	OFP	INC	X		
	F–16 SMS	OFP	INC	X		
	F–16 HUD	OFP	INC	X		
SM–ALC	F–111F	OFP	X	X	X	
	F–111D	OFP	INC	X		
	FB–111A	OFP	X	X		X
WR–ALC	APR–38	EW	X	X	X	
	ALQ–155	EW	X	X		X
	ALQ–131	EW	X	X	X	
	ALR–69	EW	INC	X	X	X
	ALR–46	EW	INC	X		
	ALR–62	EW	X	X	X	
OC–ALC	E–3A	CE	X	X	X	
	A–7	OFP	X	X	X	
PMTC	F–14	OFP		X		

SYSCON personnel to maintain as consistent an understanding of the questions as possible. The results were coded, edited, and read into a computer for final analysis.

4.4.1 Historical Data.

The historical data was usually obtained from either the lead engineer or the supervisor for each software support staff. Once all of the questions were answered, the descriptive data was simply summarized. The cost data, however, had to be normalized to remove the exogenous factors which affect the costs for the various systems differently.

For example, a GS-11 employee's annual salary may vary considerably depending on his or her step. To compensate for this exogenous cost difference, an average annual salary for each grade was derived. Another example concerns the number of personnel managed by a supervisor. For one group the ratio might be ten workers per supervisor. For another group it might be six. The model assumes an average figure.

All of these normalization factors and their FY 1981 values are provided in TABLES 1-A through 1-D

When determining the actual values of the normalization factors, SYSCON employed an expert panel approach to determine the most reasonable values. This was necessary because the data available was limited and not subject to statistical analysis. It should be noted that the explanations provided below include the input and judgement from several individuals. Thus, a particular value that might be referred to as an average may not actually equal the arithmetic average of all the data available. It simply reflects the concensus of the entire group for the most reasonable figure.

TABLE 1-A

DEFAULT VALUES FOR NORMALIZATION FACTORS

ORGANIC LABOR COST/MANMONTH BY GRADE	SEE TABLE 1-B
CONTRACTOR LABOR COST/MANMONTH	$7,000
SUPERVISION RATIO	.13
ADMINISTRATIVE RATIO	.13
SUPERVISION COST/MANMONTH	$4,390
ADMINISTRATIVE COST/MANMONTH	$1,847
ADMINISTRATIVE COMPLEXITY FUNCTION	$y = .005x + 1$
Where y = complexity factor	
x = % of work by contractor	
INFLATION FACTORS	SEE TABLE 1-C
T&E RATIO	OFP: 3%, EW: 5%, CE: 3.5%
COST/HOUR/TEST AIRCRAFT TYPE	SEE TABLE 1-D
COST/REPRODUCTION BY MEDIUM	SEE TABLE 1-D
MEDIUM REPRODUCTION FACTOR	SEE TABLE 1-D
TECHNICAL SPACE/PERSON	275 SQUARE FEET
SUPERVISORY SPACE/PERSON	130 SQUARE FEET
BUILDING COST/SQUARE FOOT	$136
UTILITY COST/SQUARE FOOT	$1.20
FURNISHING COST/PERSON	$680
MATERIALS AND SUPPLIES COST/PERSON	$700
GENERAL COMPUTER COST/PERSON	$20,000
HARDWARE MAINTENANCE COST RATIO	10%

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TABLE 1-B
DEFAULT VALUES FOR ORGANIC LABOR COSTS/MANMONTH

GRADE	LABOR COST ($)
GS-7 (AND UNDER)	1,847
GS-9	2,502
GS-11	2,969
GS-12	3,576
GS-13	4,390
GS-14	5,162
0-1 (AND UNDER)	1,994
0-2	2,477
0-3	3,168
0-4 (AND ABOVE)	4,516

TABLE 1-C
DEFAULT VALUES FOR INFLATION FACTORS

YEAR	FACTOR	YEAR	FACTOR	YEAR	FACTOR	YEAR	FACTOR
1970	.409	1984	1.364	1998	4.936	2012	17.812
1971	.431	1985	1.499	1999	5.409	2013	19.522
1972	.454	1986	1.643	2000	5.929	2014	21.396
1973	.479	1987	1.800	2001	6.498	2015	23.450
1974	.512	1988	1.973	2002	7.122	2016	25.701
1975	.561	1989	2.163	2003	7.806	2017	28.168
1976	.606	1990	2.371	2004	8.555	2018	30.872
1977	.652	1991	2.598	2005	9.376	2019	33.836
1978	.704	1992	2.848	2006	10.276	2020	37.085
1979	.786	1993	3.121	2007	11.263	2021	40.645
1980	.894	1994	3.421	2008	12.344	2022	44.547
1981	1.000	1995	3.749	2009	13.529	2023	48.823
1982	1.122	1996	4.109	2010	14.828	2024	53.510
1983	1.244	1997	4.503	2011	16.252	2025	58.647

TABLE 1-D
ADDITIONAL DEFAULT VALUES

	CARGO	BOMBER	FIGHTER	SURVEILLANCE
COST/FLIGHT TEST HOUR	$2,000	$5,000	$2,000	$ 6,000

	MYLAR TAPE	PROM	MAG TAPE
COST/REPRODUCTION	$35	$20	$17

MEDIUM	MEDIUM FACTOR
MYLAR TAPE	.12
PROM	LINES OF CODE X 1.1 over K[1]
MAG TAPE	OFP: 2 CE: 25

NOTE: THE MEDIUM FACTOR IS UNDEFINED AND IS USED AS A GENERAL CONVERSION FACTOR TO RELATE PROGRAM SIZE TO AN AVERAGE NUMBER OF TAPES OR PROMS REQUIRED PER FIELDED SYSTEM.

[1]K = NUMBER OF LINES OF CODE ON ONE PROM (IN THOUSANDS)

FIRST YEAR	K
BEFORE 1981	.25
1981-1982	.50
1983-1985	1.00
AFTER 1985	2.00

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See APPENDIX D for a summary of the data from which most of the decisions were based. A discussion of each normalization factor follows.

4.4.1.1 Organic Labor Cost/Manmonth By Grade

The organic labor cost/manmonth by grade is assumed to be the same for all personnel within each grade. This was determined separately for civilian and military grades and is used to normalize the historical direct labor cost for maintaining the software for the most recent block change. See TABLES 2-A and 2-B for the derivation of these normalization factors.

4.4.1.2 Contractor Labor Cost/Manmonth

The contractor labor cost/manmonth is assumed to be $7,000 for fiscal year 1981. This figure is based on the historical data collected which indicated a range of $4500 to $10,000. The chosen figure seems to best reflect the average for contractors, either on-site or off-site.

The contractor labor cost/manmonth is used to convert contractor manmonths to contractor costs. This normalization is necessary to account for the varying rates that are charged by different contractors.

4.4.1.3 Supervision Ratio

The supervision ratio is the inverse of the employees per supervisor. Actual data indicated that supervisors managed from three to fourteen people. An average figure of 7.7 was assumed to reflect all of the ALC's. Thus, the supervision ratio is computed as follows:

$$1 \div 7.7 = .13$$

TABLE 2-A

DERIVATION OF ANNUAL LABOR COSTS/MANMONTH

GS Grade	Annual Base Salary 9/16/81 1/	Annual Base Salary 10/1/81 2/	Retirement 3/	Life Insurance 3/	Health Insurance 3/	Secondary Benefits 3/	Average Annual Costs 4/	Average Monthly Costs 5/
Below GS 9	$15,854 6/	$16,615	$4,685	$ 50	$760	$ 50	$22,160	$1,847
GS 9	21,678	22,719	6,407	68	760	68	30,022	2,502
GS 11	25,836	27,076	7,635	81	760	81	35,633	2,969
GS 12	31,230	32,729	9,230	98	760	98	42,915	3,576
GS 13	38,465	40,311	11,368	121	760	121	52,681	4,390
GS 14	45,118	47,284	13,616	142	760	142	61,944	5,162

1/ Average annual base salaries by grade received 10/21/81 from Mr. Jerry Carter, HQTRS AFLC/MPKP at WPAFB. Figures are for 9/16/81.
   See APPENDIX E.

2/ Factor of 1.048 applied to previous column to reflect the across-the-board cost-of-living increase on 10/1/81.

3/ An Office of Personnel Management Study completed 7/1/81 (Applicable Document No. 5) provided the following information:

Labor Cost Catory	Amount of Cost
Retirement	28.2% of base salary
Life Insurance	.3% of base salary
Health Insurance	760 per year
Secondary Benefits	.3% of base salary

4/ Sum of five previous columns

5/ Previous column divided by 12

6/ Assumes average of GS 5 and GS 7 equally weighted

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TABLE 2-B

DERIVATION OF MILITARY LABOR COSTS/MANMONTH

Grade Level	Average Monthly Base Salary[1]	Average Monthly Costs[2]
Below 0-2	$1,329[3]	1,994
0-2	1,651	2,477
0-3	2,112	3,168
Above 0-3	3,010[4]	4,516

[1] Average monthly base salaries by grade were received 10/27/81 from Mr. Jerry Carter, HQTRS AFLC/NPKP at WPAFB. Figures are for 10/1/81. See APPENDIX E

[2] Previous column multipled by 1.50. Overall civilian's benefit factor is about 1.33. Since military benefits include housing and food allowances, 1.50 is used as an estimate.

[3] Assumes 0-1

[4] Assumes average of 0-4, 0-5, and 0-6 equally weighted.

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4.4.1.4 Administrative Ratio

The administrative ratio is similar to the supervision ratio but reflects the number of administrative personnel required to serve the software support staff. Actual data showed that the number of workers per supervisor and administrator was nearly the same. Therefore, the administrative ratio was assumed to be the same, i.e, .13.

4.4.1.5 Supervision Cost/Manmonth

The supervision cost/manmonth is assumed to be the same for all supervisors. Since this person is usually a grade GS 13, the average cost/manmonth for this grade is assumed to apply. As shown in TABLE 2-A, the figure is $4,390.

4.4.1.6 Administrative Cost/Manmonth

The administrative cost/manmonth is assumed to be the same for all administrators. Since this person is usually a secretary below a grade 9, the average cost/manmonth for a grade below GS 9 applied. As shown in TABLE 2-A, the figure is $1,847.

4.4.1.7 Administrative Complexity Function

The administrative complexity function is designed to reflect the increase in administrative costs due to the monitoring of outside contractors. This equation is derived from subjective information requested as part of the Phase I questionnaire. The question reads as follows:

Describe the relative increase, if any, in administrative costs caused by increasing the amount of work contracted. Assume that if 0% of the work is performed by contractors, the value is 1.00. For example, if you feel that contracting 50% of the work would increase administrative costs by 20%, you would write 1.20 below the 50 percent column.

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	% of work contracted				
	0	25	50	75	100
Relative increase in administrative costs	1.00	—	—	—	—

The average of all answers reflect the following relative cost increases:

	% of work contracted				
	0	25	50	75	100
Relative increase in administrative costs	1.00	1.125	1.25	1.375	1.50

Incorporating this information into a continuous function results in the following equation:

$$y = .005X + 1$$

where y = relative increase in administrative costs
x = % of work contracted

4.4.1.8 Inflation Factors

The inflation factors are used to normalize costs such that costs referring to different periods of time can be compared. These factors remove the impact of price increases directly tied to inflation.

The inflation factors were provided by the Air Force and are current for October 1981. For all years after 1986 an annual inflation rate of 9.6% is assumed.

4.4.1.9 T&E Ratio

The T&E ratio is used to estimate the number of actual hours in the air for testing the new software after changes have been completed. The T&E ratio is defined as the number of manhours required for testing and evaluating the software (in the lab) divided by the number of hours required to test the software actually onboard the aircraft (in the air).

The average figures selected are estimated from the historical data available. Because it appears that system type impacts the amount of T&E required in the air, three separate factors are used. These are listed below:

System Type	T&E Ratio
OFP:	3.0%
EW:	5.0%
CE:	3.5%

4.4.1.10 Cost/Flight Test Hour By Aircraft Type

The cost/flight test hour by aircraft type represents the hourly cost for testing the updated embedded computer software under actual circumstances. This is the cost of flying the airplane as well as using the test range.

The historical data indicates varying costs per hour for testing depending upon the type of aircraft being used. The amounts selected as most representative are shown below:

	Aircraft Type			
	Cargo	Bomber	Fighter	Surveillance
Cost/Flight Test Hour	$2,000	$5,000	$2,000	$6,000

4.4.1.11 Cost/Reproduction By Medium

The cost/reproduction by medium is used to estimate the cost necessary to duplicate the updated software and install it on the aircraft in the field. There are three primary media for copying the software: mylar tape, PROM, and magnetic tape. The unit medium costs are $35, $20, and $17, respectively.

Associated with each of these media is an undefined factor called the medium factor. The medium factor is used to convert program size to an

average number of tapes or PROMs required per fielded system. The medium factor is .12 for mylar tape. This indicates that only a portion of the entire role of mylar tape is required per system. For PROMS the medium factor is related to the number of lines of code and a constant, K, which takes into account technological changes over time. The medium factor is:

Medium Factor (PROM)= $$\frac{\text{Lines of code X 1.1}}{K}$$

Where K = .25 before 1981
       K = .50 between 1981 and 1982
       K = 1.00 between 1983 and 1985
       K = 2.00 after 1985

This factor divides the lines of code by the amount of code able to fit on a PROM, while assuming 10% spoilage. The amount of code able to fit on a PROM is expected to increase over time, as indicated by the time-dependent values of K.

The medium factor for magnetic tape is different depending on the system application. The number of tapes necessary on average for an OFP application is 2. For CE, the number of tapes required is significantly higher. The value chosen is 25.

4.4.1.12 Space/Person

The space/person normalization factor is used to estimate the amount of building space required once the number of people has been estimated by the model. For technical personnel, the number of square feet per person is 275. This includes space for lab equipment, desks, chairs, shelves, floors, and anything else.

Since supervisors do not necessarily require space for equipment, a smaller space is required. An office of 10 feet by 13 feet or 130 square feet

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is assumed to be representative.

4.4.1.13 Building Cost/Square Foot

The building cost/square foot is used to estimate the facility cost for sheltering a software support staff. Although building costs vary considerably all over the country, $136 per foot is assumed to be representative for this nonrecurring cost.

4.4.1.14 Utility Cost/Square Foot

The utility cost/square foot is used to account for utility costs associated with a building. This recurring cost varies considerably depending on the climate experienced by a particular region. The figure chosen to be most representative is $1.20.

4.4.1.15 Furnishing Cost/Person

The furnishing cost/person accounts for the nonrecurring costs of supplying employees with their everyday needs: desks, chairs, filing cabinets, etc. An amount of $680 is assumed.

4.4.1.16 Materials and Supplies Cost/Person

The materials and supplies cost/person includes recurring costs necessary to supply each employee. This includes pens, pencils, paper, desk pads, paper clips etc. The amount assumed is $700 per year.

4.4.1.17 General Computer Cost/Person

The general computer cost/person is used to estimate the computer

hardware and other peripheral costs that are assigned to, and used by, more than one staff of people. This nonrecurring cost is assumed to be $20,000.

4.4.1.18 Hardware Maintenance Cost Ratio

The hardware maintenance cost ratio is used to estimate the recurring cost of maintaining the computer, peripherals, and other lab equipment. Based on the data available it appears that maintenance costs are approximately 10% of the original hardware acquisition cost.

4.4.2 Subjective Data.

The subjective data is obtained from members of the software support staffs at each of the locations visited. These people work with the embedded computer software everyday. They have an indepth knowledge of the procedures required and know better than anyone else how certain characteristics in the software affect their time.

The Phase II questionnaire was given to several people at once and adminstered by SYSCON personnel. In this way, a consistent understanding of the questions would be relayed to the respondents to insure reliability of answers to the maximum extent possible. Thirty-nine questionnaires were completed, thirty-six by Air Force personnel. These included both civilian and military. APPEND: F lists the names of the respondents and their locations.

The approach used to obtain the subjective information is known as the Delphi Technique. Generally, the Delphi Technique is applicable to situations where real answers are unknown--usually some sort of prediction of future events is required. This is precisely the situation here. The objective is to predict how changes in certain system characteristics will impact on costs.

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The Delphi Technique calls for the opinions of expert panelists. The original responses are tallied and summarized. The panalists are then notified of the average answers of the group as a whole. Each has an opportunity to change any of his/her answers based on this additional knowledge. The final answers are then tallied and readied for analysis.

All of the Phase II responses were received by December 1981. The answers were coded and fed into SYSCONs' Hewlett Packard 3000 computer. Next, the numbers were averaged and summarized. Each respondent was then sent a computer-generated letter indicating how his answers compar d to the groups' averages. A sample of this letter is shown in APPENDIX G. Each respondent was given the opportunity to make any changes and forward the results back to SYSCON. All questionnaires were completed and returned by February 1982.

The data changes were made so that the files could be updated. The files were then fed into a statistical package to ensure that the new answers could be edited for completeness and consistency and readied for statistical analysis.

There were two types of statistical analyses performed on the data. First, the answers were simply averaged to derive the general trend. This was all that was necessary for several of the questions that simply asked for ordinal[1]/ (ranking) data.

The other questions asked for ratio type data, which is susceptible to more sophisticated statistical analyses. For these questions, linear and

[1]/There are four types of data: nominal, ordinal, interval, and ratio. Nominal data, such as the numbers on the back of baseball players' uniforms, cannot be maniputed. On the other end of the scale is ratio data. An example is the number of home runs hit by baseball players during the year. Ratio data can be manipulated such that adding or dividing two totals is meaningful. For more information on this subject see any standard statistical test book, including Research for Marketing Decisions, Paul E. Green and Donald S. Tull, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1970, pages 174-181.

nonlinear regression analysis was used to derive arithmetic equations that statistically represent the data. This also provided statistical criteria for measuring how well the equations reflected the data. In each case an exponential and a linear relationship were tested. Where further testing was deemed necessary, a logarithmic equation form was tried. The shape which exhibited the best fit according to the statistical criteria was chosen. Computer printouts of the statistical results have been provided to the Air Force under separate cover.

The results of the regression analyses discussed above are shown in TABLE 3. TABLE 4 summarizes the modification factors for those characteristics not susceptible to regression analysis. Each derivation is discussed below.

4.4.2.1 Lines of Code

The question on lines of code is designed to measure how changes in the embedded computer software size affect costs. The hypothesis is that the larger the program, the more difficult to change and update the software, causing costs to increase. As shown in TABLE 3, the shape of equations varies between exponential and a straight line, depending upon the work phase in question.

The cost of maintaining the support software is assumed to be independent of the embedded computer software size.

4.4.2.2 Percent Memory Fill

The percent memory fill is important since as this characteristic approaches 100%, additional lines of code will require some deletion of old code. Obviously, time and costs would increase substantially to accomplish this.

TABLE 3
MODIFICATION EQUATIONS

PHASE

	1. LINES OF CODE	2. % MEMORY FILL [1]	3. % TIMING FILL [1]	4. % WORK CONTR. [2]	5. YEAR OF SUPPORT [3]	6. No. FIELDED SYS.	7. CHANGE EFF.
REQUIREMENTS REVIEW	$.0255X + .587$	$1.42X^{.806}$	$1.33X^{.624}$	$.0762(lnx)+1.34$	$1.61X^{-.361}$	$.0266X+.985$	1
DESIGN	$.239X^{.539}$	$2.00X^{1.50}$	$1.82X^{1.30}$	$.0801(lnx)+1.36$	$1.64X^{-.375}$	$.0109X+.995$	$2.06X^{-.900}$
DEVELOPMENT	$.231X^{.544}$	$1.88X^{1.35}$	$1.82X^{1.31}$	$.0666(lnx)+1.30$	$1.65X^{-.374}$	$.0109X+.996$	$2.06X^{-.900}$
INTEGRATION	$.265X^{.506}$	$1.59X^{.978}$	$1.55X^{.904}$	$.0593(lnx)+1.28$	$1.65X^{-.366}$	$.0579X+.965$	$2.06X^{-.900}$
TEST & EVALUATION	$.295X^{.461}$	$1.32X^{.607}$	$1.39X^{.688}$	$.0666(lnx)+1.29$	$1.58X^{-.330}$	$.052X+.954$	$2.06X^{-.900}$
DOCUMENTATION	$.027X + .562$	$1.13X^{.307}$	$1.09X^{.182}$	$.284X+1.03$	$1.43X^{-.258}$	$.00805X+.994$	$2.06X^{-.900}$
REPRODUCTION/ INSTALLATION	$.708X^{.130}$	$1.04X^{.095}$	$1.04X^{.148}$	1	$1.19X^{-.119}$	$1.26X+.338$	1
SUPPORT SOFTWARE	1	1	1	$.0666(lnx)+1.30$	$1.65X^{-.374}$	1	$2.06X^{-.900}$

NOTE: X = VALUE OF THE INDICATED SYSTEM CHARACTERISTIC

[1] IF X=74 OR LESS FOR THIS CHARACTERISTIC, THEN SUBSTITUTE THE VALUE 75 INTO THE MODIFICATION EQUATION.

[2] IF X=0 FOR THIS CHARACTERISTIC, THEN THE MODIFICATION EQUATION IS SET EQUAL TO 1.

[3] IF X=7 OR GREATER FOR THIS CHARACTERISTIC, THEN SUBSTITUTE THE VALUE 6 INTO THE MODIFICATION EQUATION.

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TABLE 4
MODIFICATION FUNCTIONS

PHASE	8. LANGUAGE		
	ASSEMBLY	FORTRAN	STRUCTURED HOL
REQUIREMENTS REVIEW	1.00	.94	.91
DESIGN	1.00	.84	.78
DEVELOPMENT	1.00	.67	.62
INTEGRATION	1.00	.83	.76
TEST & EVALUATION	1.00	.87	.82
DOCUMENTATION	1.00	.82	.75
REPRO/INSTALLATION	1.00	.95	.91
SUPPORT SOFTWARE	1.00	1.00	1.00

PHASE	9. DEVELOPMENT V&V RATING (YEAR OF SUPPORT = 1)		
	NONE	DEVELOPER	COMPLETE
REQUIREMENTS REVIEW	1.41	1.00	.90
DESIGN	1.56	1.00	.80
DEVELOPMENT	1.65	1.00	.81
INTEGRATION	1.68	1.00	.78
TEST & EVALUATION	2.05	1.00	.67
DOCUMENTATION	1.68	1.00	
REPRO/INSTALLATION	1.18	1.00	.96
SUPPORT SOFTWARE	1.00	1.00	1.00

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TABLE 4
MODIFICATION FUNCTIONS

9. DEVELOPMENT V&V RATING
(YEAR OF SUPPORT = 2)

PHASE	NONE	DONE BY DEVELOPER	TOTAL IV & V COMPLETE
REQUIREMENTS REVIEW	1.14	1.00	.96
DESIGN	1.20	1.00	.92
DEVELOPMENT	1.23	1.00	.91
INTEGRATION	1.24	1.00	.85
TEST & EVALUATION	1.37	1.00	.85
DOCUMENTATION	1.24	1.00	.93
REPRO/INSTALLATION	1.06	1.00	.99
SUPPORT SOFTWARE	1.00	1.00	1.00

9. DEVELOPMENT V&V RATING
(YEAR OF SUPPORT = 3)

PHASE	NONE	DONE BY DEVELOPER	TOTAL IV & V COMPLETE
REQUIREMENTS REVIEW	1.04	1.00	.99
DESIGN	1.06	1.00	.98
DEVELOPMENT	1.07	1.00	.98
INTEGRATION	1.07	1.00	.97
TEST & EVALUATION	1.11	1.00	.95
DOCUMENTATION	1.07	1.00	.98
REPRO/INSTALLATION	1.02	1.00	1.00
SUPPORT SOFTWARE	1.00	1.00	1.00

NOTE: IF YEAR OF SUPPORT IS 4 OR MORE, THEN THE MODIFICATION VALUE FOR DEVELOPMENT V & V RATING IS 1.00;

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TABLE 4
MODIFICATION FUNCTIONS

10. PROGRAM DESIGN

PHASE	POOR	FAIR	GOOD	EXCELLENT
REQUIREMENTS REVIEW	1.00	.93	.87	.79
DESIGN	1.00	.85	.72	.58
DEVELOPMENT	1.00	.85	.73	.59
INTEGRATION	1.00	.87	.74	.60
TEST & EVALUATION	1.00	.91	.80	.70
DOCUMENTATION	1.00	.89	.78	.67
REPRO/INSTALLATION	1.00	.97	.95	.91
SUPPORT SOFTWARE	1.00	1.00	1.00	1.00

11. PROGRAM IMPLEMENTATION

PHASE	POOR	FAIR	GOOD	EXCELLENT
REQUIREMENTS REVIEW	1.00	.96	.91	.86
DESIGN	1.00	.89	.80	.69
DEVELOPMENT	1.00	.86	.73	.61
INTEGRATION	1.00	.87	.74	.61
TEST & EVALUATION	1.00	.89	.80	.70
DOCUMENTATION	1.00	.92	.84	.74
REPRO/INSTALLATION	1.00	.96	.93	.89
SUPPORT SOFTWARE	1.00	1.00	1.00	1.00

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TABLE 4
MODIFICATION FUNCTIONS

12. INITIAL DOCUMENTATION
(YEAR OF SUPPORT = 1)

PHASE	NONE	INCOMPLETE OUTDATED	MIL-STD UP-TO-DATE
REQUIREMENTS REVIEW	2.84	1.00	.65
DESIGN	3.97	1.00	.56
DEVELOPMENT	3.57	1.00	.61
INTEGRATION	3.79	1.00	.62
TEST & EVALUATION	3.13	1.00	.68
DOCUMENTATION	4.11	1.00	.52
REPRO/INSTALLATION	2.04	1.00	.84
SUPPORT SOFTWARE	1.00	1.00	1.00

12. INITIAL DOCUMENTATION
(YEAR OF SUPPORT = 2)

PHASE	NONE	INCOMPLETE OUTDATED	MIL-STD UP-TO-DATE
REQUIREMENTS REVIEW	1.64	1.00	.84
DESIGN	2.04	1.00	.78
DEVELOPMENT	1.90	1.00	.82
INTEGRATION	1.98	1.00	.82
TEST & EVALUATION	1.75	1.00	.86
DOCUMENTATION	2.09	1.00	.76
REPRO/INSTALLATION	1.36	1.00	.94
SUPPORT SOFTWARE	1.00	1.00	1.00

NOTE: IF YEAR OF SUPPORT IS 4 OR MORE, THEN THE MODIFICATION VALUE FOR INITIAL DOCUMENTATION IS 1.00.

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TABLE 4
MODIFICATION FUNCTIONS

12. INITIAL DOCUMENTATION
(YEAR OF SUPPORT = 3)

PHASE	NONE	INCOMPLETE OUTDATED	MIL-STD UP-TO-DATE
REQUIREMENTS REVIEW	1.18	1.00	.95
DESIGN	1.30	1.00	.93
DEVELOPMENT	1.26	1.00	.94
INTEGRATION	1.28	1.00	.94
TEST & EVALUATION	1.21	1.00	.96
DOCUMENTATION	1.31	1.00	.92
REPRO/INSTALLATION	1.10	1.00	.98
SUPPORT SOFTWARE	1.00	1.00	1.00

13. TYPE OF AIRCRAFT

PHASE	CARGO	BOMBER	FIGHTER	SURVEILLANCE
REQUIREMENTS REVIEW	.83	1.02	1.00	.98
DESIGN	.80	1.02	1.00	1.01
DEVELOPMENT	.80	1.01	1.00	1.02
INTEGRATION	.79	1.05	1.00	1.02
TEST & EVALUATION	.80	.99	1.00	1.01
DOCUMENTATION	.89	1.02	1.00	.99
REPRO/INSTALLATION	.90	1.00	1.00	.99
SUPPORT SOFTWARE	1.00	1.00	1.00	1.00

NOTE: IF YEAR OF SUPPORT IS 4 OR MORE, THEN THE MODIFICATION VALUE FOR INITIAL DOCUMENTATION IS 1.00.

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TABLE 4
MODIFICATION FUNCTIONS

PHASE	14. COMPLEXITY				
	1	2	3	4	5
REQUIREMENTS REVIEW	.74	.86	1.00	1.56	2.27
DESIGN	.52	.75.	1.00	2.15	3.60
DEVELOPMENT	.51	.75	1.00	2.15	3.60
INTEGRATION	.59	.80	1.00	2.08	3.40
TEST & EVALUATION	.65	.83	1.00	1.71	2.87
DOCUMENTATION	.69	.86	1.00	1.65	2.68
REPRO/INSTALLATION	.97	.99	1.00	1.05	1.10
SUPPORT SOFTWARE	.51	.75	1.00	2.15	3.60

PHASE	15. RATE OF CHANGE				
	1	2	3	4	5
REQUIREMENTS REVIEW	.64	.76	1.00	1.42	2.12
DESIGN	.62	.77	1.00	1.60	2.39
DEVELOPMENT	.61	.78	1.00	1.62	2.50
INTEGRATION	.61	.77	1.00	1.62	2.48
TEST & EVALUATION	.62	.77	1.00	1.62	2.43
DOCUMENTATION	.55	.72	1.00	1.86	2.68
REPRO/INSTALLATION	.67	.79	1.00	1.42	1.99
SUPPORT SOFTWARE	.61	.78	1.00	1.62	2.50

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TABLE 4
WORK EFFICIENCY (TIME)

PHASE	16. SKILL LEVEL MIX				
	1	2	3	4	5
REQUIREMENTS REVIEW	3.20	1.94	1.00	.73	.55
DESIGN	3.86	2.18	1.00	.69	.47
DEVELOPMENT	3.68	2.12	1.00	.69	.48
INTEGRATION	3.95	2.33	1.00	.69	.49
TEST & EVALUATION	3.21	1.91	1.00	.74	.58
DOCUMENTATION	2.77	1.69	1.00	.78	.62
REPRO/INSTALLATION	1.83	1.36	1.00	.88	.79
SUPPORT SOFTWARE	3.68	2.12	1.00	.69	.48

NOTE: CONTRACTORS ARE ASSUMED TO WORK AS EFFICIENTLY AS SKILL
LEVEL MIX 5. IF CONTRACTOR IS PRESENT, WORK EFFICIENCY IS THE
WEIGHTED AVERAGE OF CONTRACTOR SKILL LEVEL MIX AND THE
ORGANIC SKILL LEVEL MIX.

11-6-82-19

Once the regression equation was selected, a further adjustment was necessary. Since regression analysis assumes a continuous function, the resulting equation reflects a relationship over all possible values for percent memory fill. To compensate for the unnecessary need of concern to reduce program size for low percentages, SYSCON judged that deletion of lines of code does not become important until the percent memory fill reaches 75%. Only as the percentage becomes 75% or greater does this concern become significant enough to affect costs. Thus, percentages of less that 75 are assumed to have no impact on cost causation.

The cost of maintaining the support software is assumed to be independent of the embedded computer software.

4.4.2.3 Percent Timing Fill

The percent timing fill is important for the same reason as percent memory fill. As the percent reaches 100%, additional program adjustments may be necessary to reduce timing constraints when the software is updated.

The exponential equations were chosen for each of the seven work phases. As with percent memory fill, percentages below 75% are assumed to have no impact on costs. Moreover, the percent timing fill has no effect on the support software maintenance costs.

4.4.2.4 Percent of Work Performed by Contractors

This characteristic is used to estimate costs associated with using outside help to perform the work. The hypothesis is that hiring outside people will cause some duplication of work, as well as additional costs for monitoring the effort.

The regression equations which best reflected the data indicate a logarithmic shape, except for documentation. For the latter, a linear shape was best.

The equations indicate that costs rise as the percentage of work performed by contractors rises. However, after a certain percentage, perhaps 30%, the amount of rise tends to slow considerably.

With this characteristic, support software costs are expected to change in the same manner as software development costs. However, reproduction/installation costs are unaffected by the percent of work performed by contractors.

4.4.2.5 Year of Support

This characteristic is designed to account for the time necessary to become completely familiar with the software. The hypothesis is that as time progresses, maintenance cost will decline (all other factors remaining the same).

The equations indicate that costs decrease exponentially as time (year of support) increases. This is indicated by the negative sign in the exponent.

It is also hypothesized that at some time a point of diminishing returns would be reached, whereby further familiarization with the code has no cost impact. SYSCON judged that after the sixth year, this factor will have no impact on cost causation, therefore the questionaire allowed for an impact from this characteristic only for the first six years of support.

The equation for support software is assumed to be the same as derived for the development phase.

4.4.2.6 Number of Fielded Systems

The number of fielded systems has only a small cost effect on software support. However, because the regression equations for this factor are statistically significant, SYSCON allowed the model to incorporate the small effect into its cost estimating algorithm.

This factor has no impact on maintaining the support software.

4.4.2.7 Change Efficiency

The question regarding change efficiency is designed to gain a measure of the amount of work performed compared to the amount of work requested. Thus, change efficiency is the number of changes to be completed by the software support staff divided by the number of changes requested by the user. Its effect on cost is the same for each of the work phases, except requirements review and reproduction, where it is assumed to have no effect.

The equation derived is exponential and shows a significant impact as the amount of work to be completed is increased. This is as expected.

4.4.2.8 Language

The language of the software is expected to impact the costs of software maintenance. The question lists three alternatives and requests opinions as to what extent costs are impacted. The results shown in TABLE 4 are simply the arithmetic means for all who responded to the question. As hypothesized, a program written in a structured-higher order language, rather than assembly language, is shown to reduce substantially the costs of supporting the software, all other factors remaining the same.

The language of the embedded computer software does not affect the cost of maintaining the support software.

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4.4.2.9 Development V&V Rating

The development verification and validation (V&V) rating is a measure of how well the software as originally developed performs. As expected, the results of the survey show that maintenance costs will diminish as the development V&V rating improves.

In TABLE 4, for year of support equal to 1, the numbers shown provide the actual computed averages of responses. However, SYSCON hypothesizes that after the third year of support, the support staff has made sufficient changes in the software that the V&V rating would no longer have an impact on the support costs. Thus, after the third year this function reverts to all 1's.

For the year of support equal to 2 and 3, a stepwise adjustment was required to smooth out the reduction of importance for this factor over time. SYSCON judged that 100% of the impact for V&V rating is felt during the first year of support, 35% during the second year, 10% during the third year, and 0% thereafter . Thus, the following equations are used to adjust the originally computed averages:

For values greater than one (unity):

$$(X-1) \ W + 1 \qquad (1)$$

For values less than one (unity):

$$\frac{1}{(1/X-1) \ W + 1} \quad (2)$$

where X = original factor

W = weight (% of full impact)

For equation (1), 1 is substracted from the original factor to obtain the amount of impact. (For example, 1.80 means an 80% increase.) This is then

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multiplied by the weight. (That is, 35% of 80% would be 28%). One is then added back to get the new factor. (.28+1 = 1.28).

For equation (2), one must work with the reciprocal to maintain consistency. The logic and explanation is precisely the same. An illustrative example is useful.

Suppose the original factor is 1.80. This represents an 80 percent increase in costs. A second factor to exactly offset this increase is

$$1/1.80 = .555$$

Thus, a .555 factor is precisely an equal and opposite factor that would offset an 80% increase (.555 x 1.80 = 1.00).

Now apply the 35% weighting factor by using equations (1) and (2):

$$(1.8-1) \ (.35) + 1 \quad = \quad 1.28$$

$$\frac{1}{(1/.555 - 1) \ (.35) + 1} = \quad .7809$$

The 1.28 and .7809 are also equal and offsetting. (1.28 X .7809 = 1.00)

Using the two equations discussed above and the weights W=.35 for year of support = 2 and W=.10 for year of support = 3, the numbers shown in TABLE 4 can be computed. For example, the 1.41 and .90 for requirements review in the first year of support are modified to 1.14 and .96, respectively, for the second year of support. The computations are illustrated below:

$$(1.41 - 1)(.35) + 1 \quad = 1.14$$

$$\frac{1}{(1/.90 - 1)(.35) + 1} = \quad .96$$

The rest of the numbers are computed in precisely the same fashion.

Development V&V rating is assumed to have no impact on maintaining the support software.

4.4.2.10 Program Design Rating

The program design rating is a measure of how well the program was supposed to be structured. As expected, the results showed that as the program design structure improves, maintenance costs would diminish.

This factor is not expected to affect support software maintenance costs.

4.4.2.11 Program Implementation Rating

This factor is similiar to program design rating except that it is concerned with how well the program structure is actually implemented. The results are very similar to those of program design rating.

4.4.2.12 Initial Documentation Rating

The initial documentation rating is concerned with how well the documentation is at the time the development software is turned over to the support staff. The hypothesis is that little or no documentation increases support costs and vice versa.

In addition, SYSCON hypothesizes that after the third year of support, this factor diminishes in importance. As the staff reworks the software over time and redocuments the changes, the initial documentation has less and less of an impact on costs. The methodology used to smooth the impact of this factor for the second and third years of support is precisely the same as that explained above for development V&V rating.

multiplied by the weight. (That is, 35% of 80% would be 28%). One is then added back to get the new factor. (.28+1 = 1.28).

For equation (2), one must work with the reciprocal to maintain consistency. The logic and explanation is precisely the same. An illustrative example is useful.

Suppose the original factor is 1.80. This represents an 80 percent increase in costs. A second factor to exactly offset this increase is

$$1/1.80 = .555$$

Thus, a .555 factor is precisely an equal and opposite factor that would offset an 80% increase (.555 x 1.80 = 1.00).

Now apply the 35% weighting factor by using equations (1) and (2):

$$(1.8-1) \ (.35) + 1 \qquad = \qquad 1.28$$

$$\frac{1}{(1/.555 - 1) \ (.35) + 1} = \qquad .7809$$

The 1.28 and .7809 are also equal and offsetting. (1.28 X .7809 = 1.00)

Using the two equations discussed above and the weights W=.35 for year of support = 2 and W=.10 for year of support = 3, the numbers shown in TABLE 4 can be computed. For example, the 1.41 and .90 for requirements review in the first year of support are modified to 1.14 and .96, respectively, for the second year of support. The computations are illustrated below:

$$(1.41 - 1)(.35) + 1 \qquad = 1.14$$

$$\frac{1}{(1/.90 - 1)(.35) + 1} = .96$$

For example, the factors for requirements review in the first year of support are 2.84 and .65. This is shown in TABLE 4. These numbers are adjusted for the second year of support as follows:

$$(2.84 - 1)(.35) + 1 \quad = 1.64$$

$$\frac{1}{(1/.65 - 1)(.35) + 1} = .84$$

This factor has no impact on support software maintenance costs.

4.4.2.13 Type of Aircraft

The type of aircraft is judged to affect costs to a lesser degree than originally hypothesized. However, because of the significantly diminished costs associated with cargo aircraft, this factor was retained.

Type of aircraft does not affect support software maintenance costs.

4.4.2.14 Complexity Rating

This factor is a general measure of how complex the software and hardware is. The rating ranges from 1 to 5, with 5 being most complex. The definition for each of the five levels is shown in FIGURE 6.

The complexity factor is important because it has such a pronounced effect on maintenance costs. As shown in TABLE 4, the difference between a complexity rating of 1 and 5 for the software development phase is a factor of seven $(3.60/.51 = 7.06)$.

Complexity is assumed to affect support software maintenance in the same manner as it affects the development phase.

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4.4.2.15 Rate of Change

The rate of change is a measure of how difficult it is to keep up with user requests for software changes. It varies from 1 to 5. The definitions are provided in FIGURE 6.

SYSCON hypothesizes that the more stable the code is, the lower the maintenance costs and vice versa. The survey results bear this out.

For support software, the cost impact of this factor is assumed to be the same as for the development phase.

4.4.2.16 Work Efficiency/Skill Level Mix

The work efficiency/skill level mix measures the ability and experience of Air Force organic personnel. The skill level varies between 1 and 5, with 5 referring to the most experienced staff. See FIGURE 6 for the definitions.

This factor is important because experience and familiarity of the code can make a very large difference in the time required to update the software. For example, a staff of skill level mix 5 can be expected to develop new code almost eight times as fast as a skill level 1. (3.68/.48 = 7.7).

The original question in the Phase II questionnaire asks for the impact on cost (not manhours) for the various skill levels. Work efficiency/skill level is a measure of time. Thus, the results from the survey showing relative costs have to be transferred to a measure of time. A two-step process is required.

The first step is to establish an average cost/manmonth for each skill level. This applies to each member of the staff and each member is assumed to be paid the same amount. The methodology to accomplish this is shown in FIGURE 7. The results from this analysis are listed below:

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FIGURE 6

DEFINITIONS FOR COMPLEXITY, RATE OF CHANGE, AND SKILL LEVEL

Characteristic		Range of Values
Complexity	1 =	Easy to read code, many similar applications.
	2 =	Time required to gain familiarity with code, many similar applications.
	3 =	Time required to gain familiarity with code, approaching state-of-the-art.
	4 =	Extremely difficult-to-understand code, few similar applications.
	5 =	Extremely difficult-to-understand code, unique application, state-of-the-art.
Rate of Change	1 =	Stable code, changes required very infrequently, minimal staffing required.
	2 =	Infrequent changes required on a periodic basis, staffing assigned on a part-time basis.
	3 =	Changes required on a periodic basis, staffing requirements fairly constant.
	4 =	Frequent changes, changes require immediate attention, full-time staff required plus additional personnel for perturbations.
	5 =	Changes required continuously, full-time staff plus additional personnel have difficulty keeping up with user requirements.
Skill Level Mix	1 =	Predominantly inexperienced, junior personnel unfamiliar with the software system.
	2 =	Variety of personnel with limited working knowledge of the software system.
	3 =	Typical personnel with some experience with the software system, mix of junior and senior personnel.
	4 =	Predominantly senior personnel with a good working knowledge of the software system.
	5 =	Highly experienced personnel with a good working knowledge of the software system.

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FIGURE 7

DERIVATION OF COST/MANMONTH BY SKILL LEVEL

Skill Level Mix	Applied Weighting Factors [1]					Avg Cost Per [2] Manmonth
	below GS 9	GS 9	GS 11	GS 12	GS 13	
1	10%	50%	20%	15%	5%	$2,785
2	0	40	30	25	5	3,005
3	0	15	35	35	15	3,325
4	0	0	30	40	30	3,638
5	0	0	10	40	50	3,922

[1] Factors determined subjectively

[2] Applied weighting factors are multiplied by the respective average costs/manmonth for each grade.

Grade	Cost/Manmonth
below GS 9	$1,847
GS 9	2,502
GS 11	2,969
GS 12	3,576
GS 13	4,390

Skill Level	Cost Manmonth
1	$2,785
2	3,005
3	3,325
4	3,638
5	3,922

The second step is to adjust the averages of the answers obtained from the respondents who answered the Phase II questionnaire. These averages are shown in TABLE 5. Costs can be converted to time by dividing the relative cost by the cost per manmonth. That is:

$$\frac{\text{relative cost}}{\text{cost/manmonth}} = \text{relative manmonths}$$

Taking a ratio of the manmonths for two skill levels will then result in the relative differences in manmonths or time. An equation can thus be derived using the following notation:

C_x = Relative Cost/Manmonth for Skill Level x (x=1,2,...5)

I_x = Relative Cost for skill Level x

T_x = Relative Time required to perform the task for skill level x

$$\frac{I_x}{C_x} = T_x$$

If skill level 3 is considered the base from which all other skills are to be compared, then T_x/T_3 will provide a new index for time, i.e, work efficiency/skill level mix.

For example, take the first number in TABLE 5, 2.68. The relative time required for a skill level 1 staff to complete requirements review is:

$$\frac{2.68}{\$2,785} = .0009623$$

The relative time required for a skill level 3 staff to complete the same task is:

$$\frac{1}{\$3,325} = .00030075$$

Comparing the skill level 1 staff to the base staff results in the relative work efficiency:

$$\frac{.0009623}{.00030075} = 3.20$$

Thus, the skill level 1 staff will take 3.20 times as long as the skill level 3 staff.

In general the derived equation which provides the results shown in TABLE 5 is:

$$\frac{T_x}{T_3} = \frac{I_x/C_x}{I_3/C_3}$$

$$\frac{T_x}{T_3} = \frac{I_x/C_x}{1/3325}$$

$$\frac{T_x}{T_3} = \frac{3325}{C_x} \cdot I_x$$

For support software, the work efficiency for software development is assumed.

TABLE 5
RELATIVE IMPACT ON COSTS FROM SKILL LEVEL CHANGE
(PHASE II QUESTIONNAIRE RESULTS)

PHASE	SKILL LEVEL				
	1	2	3	4	5
REQUIREMENTS REVIEW	2.68	1.75	1.00	.80	.65
DESIGN	3.23	1.97	1.00	.75	.56
DEVELOPMENT	3.08	1.92	1.00	.76	.57
INTEGRATION	3.31	2.11	1.00	.76	.58
TEST & EVALUATION	2.68	1.73	1.00	.81	.68
DOCUMENTATION	2.32	1.53	1.00	.85	.73
REPRO/INSTALLATION	1.53	1.23	1.00	.96	.93

4.5 Cost Projection Algorithm

The algorithm designed for the ASSCM encompasses the Phase I historical
data, the Phase II subjective data, and the work breakdown structure to
project costs. The historical data is used to derive the normalized baseline
data. Independently, the subjective data is used to derive modification
factors. The modification factors are applied to the baseline data twice:
once to reflect representative characteristic values, and again to reflect the
characteristics specified by the model user. A schematic illustration of this
relationship is provided in FIGURE 8.

As shown in FIGURE 8, there are three major areas in which computations
take place. First, the historical data is normalized. The normalization
factors are applied to the historical data to remove outside, exogenous
factors to the extent possible. Secondly, the historic characteristics which
describe the software are changed to reflect a more typical system. To
accomplish this, the modification factors are applied to the normalized
baseline data to obtain the representative baseline data. Finally, the
representative characteristics are changed again, according to the values
selected by the model user. Applying the modification factors again, this
time to the representative baseline data, results in the final cost
projections being sought by the user. See FIGURE 9 for a schematic view of
the relationship among data bases.

A discussion of how each of the three data bases is derived follows.

4.5.1 Normalization

From the historic data collected, seven systems were chosen to comprise
the baseline data. Each represents a different application of either
operational flight program (OFP) software, airborne communications/

FIGURE 8
MODEL ALGORITHM

NORMALIZATION FACTORS

USER INPUT

NORMALIZATION (STEP 1)

ADJUSTMENTS (STEP 2)

HISTORICAL DATA (PHASE I)

INITIAL BASELINE SPECIFIC CONDITIONS REMOVED

REPRESENTATIVE BASELINE (INPUT TO MODEL)

TOTAL LABOR COST ESTIMATE

NUMBER OF MAN MONTHS NUMBER OF PERSONNEL

ESTIMATE ALL OTHER COSTS

TOTAL ANNUAL COST ESTIMATE

MODIFICATION FACTORS

11-982-0
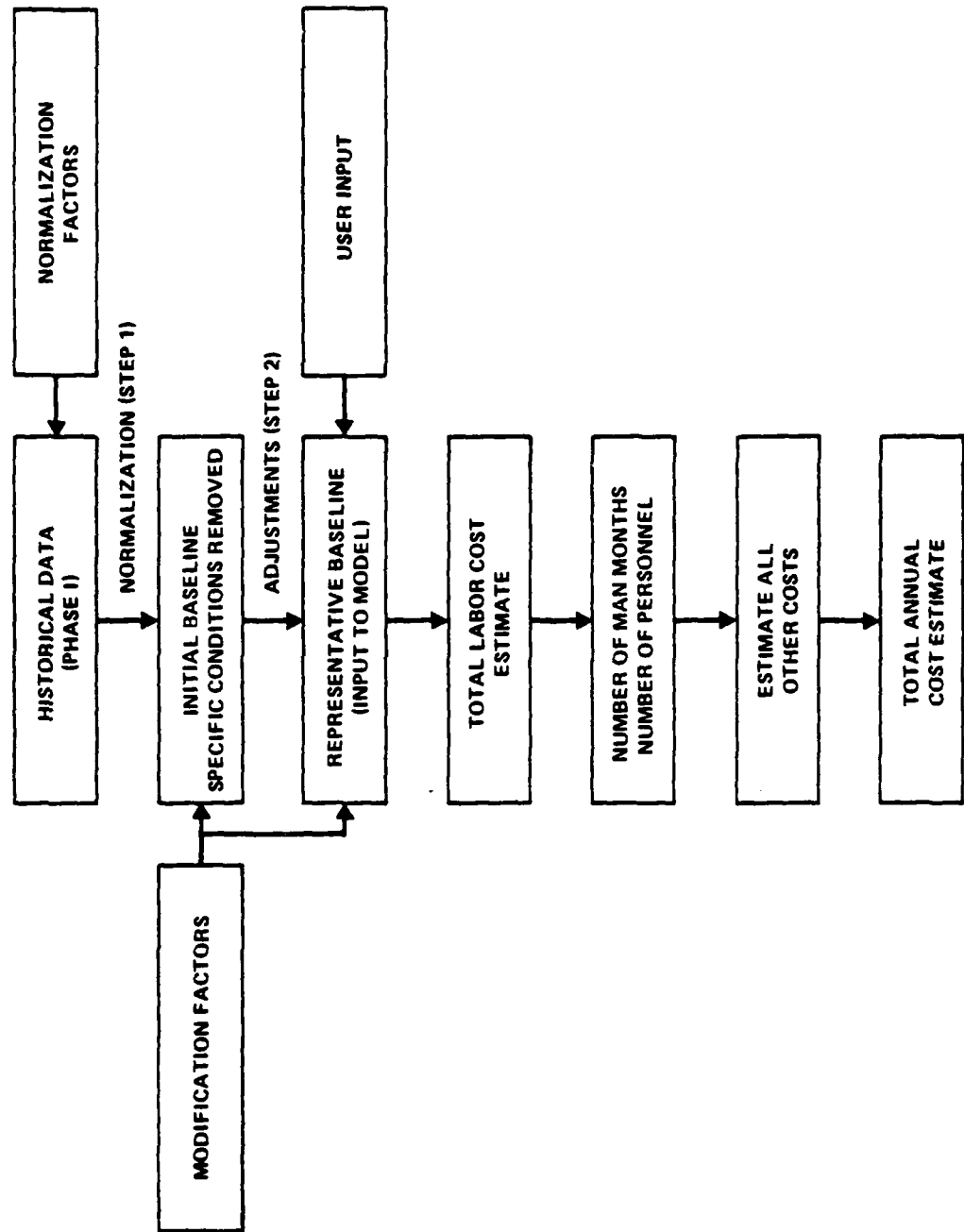
FIGURE 9
RELATIONSHIP AMONG DATA BASES

HISTORICAL SYSTEM COSTS & CHARACTERISTICS

NORMALIZATION FACTORS

NORMALIZED SYSTEM COSTS & CHARACTERISTICS

MODIFICATION FACTORS

REPRESENTATIVE SYSTEM COSTS & CHARACTERISTICS

MODIFICATION FACTORS

PROPOSED SYSTEM COSTS & CHARACTERISTICS

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11-9-82-6
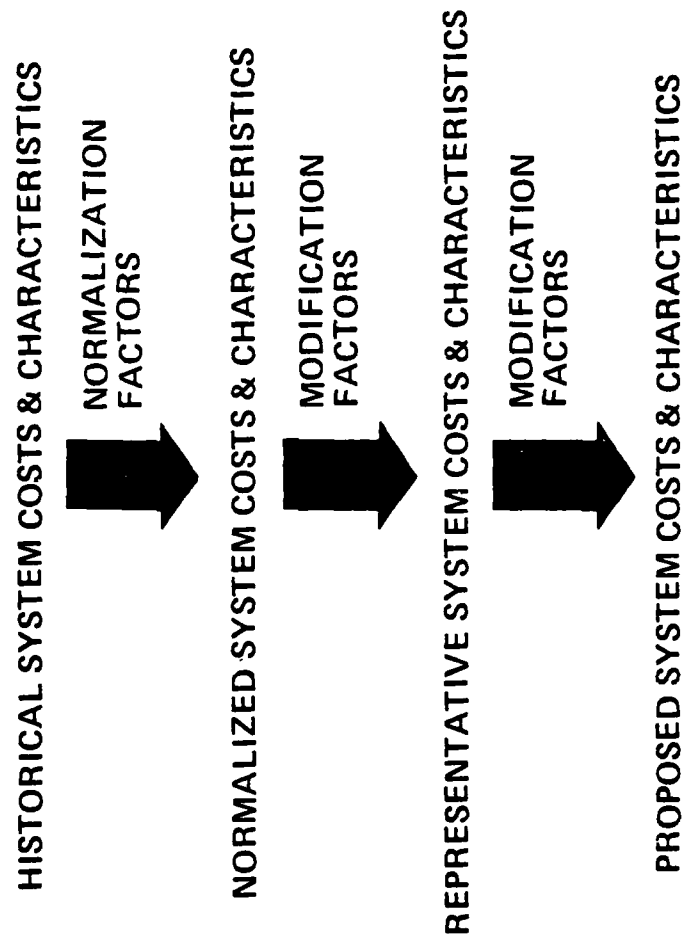
electronics (CE) software, or airborne electronic warfare (EW) software. The
actual systems and their applications are listed below:

System	Type	Application
F-16 FCC	OFP	Fire Control
F-111F	OFP	Navigation, Weapon Delivery
A-7	OFP	Navigation, Weapon Delivery, Fire Control
APR-38	EW	Integrated System
ALQ-131	EW	Jammer
ALR-62	EW	Receiver
E-3A	CE	Command and Control

The first step in the algorithm is to normalize the historical data from
these systems. Using the normalization factors discussed in sections 4.4.1.1
through 4.4.1.18, the annual cost for the most recent block change of each
system is recreated. A computer printout for the seven systems illustrating
these costs is provided in APPENDIX H. The historic characteristics which
these costs reflect are shown in TABLE 6.

4.5.2 Representative Baseline

The representative baseline data is generated to allow the cost
projections to start with a data base that is more reflective of a future
system than, perhaps, the one system for which data happened to be
available. This will enable the model to more easily handle a wide range of
characteristic values, while reducing the risk of error caused by estimating
the cost impact of changing a characteristic value from one extreme to
another.

TABLE 6
CHARACTERISTICS OF THE HISTORICAL BASELINE SYSTEMS

CHARACTERISTIC	F-111F NAVIGATION WEAPON DELIVERY OFP	ALQ-131 JAMMER EW	F-16 FCC FIRE CONTROL OFP	ALR-62 RECEIVER EW	APR-38 INTEGRATED SYS EW	A-7 NAVIGATION FIRE CONTROL WEAPON DELIVERY OFP	E-3A COMMAND & CONTROL CE
FIRST YEAR OF SUPPORT	1974	1980	1977	1978	1979	1976	1977
LINES OF CODE (K)	12	16	29.1	14	16	16	325
LANGUAGE	1	1	3	1	1	1	3
% MEMORY FILL	97.5	100	91	50	100	99	95
% TIMING FILL	99.5	95	85	100	85	91	92
DEV V&V RATING	1	1	3	1	2	2	3
DESIGN RATING	2	1	3	1	3	2	3
IMPLEM RATING	2	1	3	1	3	2	3
INIT DOC RATING	2	3	3	2	2	2	3
REPRODUCTION MEDIUM	3	1	3	2	1	1	3
AIRCRAFT TYPE	3	3	3	3	2	3	4
NO. FIELDED SYS	90	268	350	300	116	360	23
COMPLEXITY	4	4	3	3	3	5	4
RATE OF CHANGE	3	4	4	4	5	4	5
SKILL LEVEL MIX	2	4	3	2	2	4	2
CHANGE EFFICIENCY (%)	75	50	75	75	75	75	75
DIRECT SUPP'T EQUIP'T ($ MIL)							
HARDWARE(1981)	50.781	1.092	11.185	1.654	4.261	.660	4.125
SOFTWARE(1981)	23.438	4.972	5.593	1.018	4.262	.200	5.368
EXPECTED SYSTEM LIFE (Years)	10	20	25	10	10	20	15
BLOCK CHANGE LENGTH (Months)	18	12	18	12	12	20	7
SUPPORT SOFTWARE MAINTENANCE	1	1	1	1	2	1	1
% CONTRACTOR	74	0	0	21	0	15	0
LOCATION OF CONTRACTOR	1	0	0	2	0	2	0

NOTE: SEE FIGURE 2 FOR THE MEANING OF EACH NUMERICAL VALUE

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The characteristics of a typical system for each of the seven baseline applications were generated from the Phase II questionnaire. There, each respondent was asked to provide his judgment as to the representative value for each of the sixteen characteristics. After tabulating the results, SYSCON selected values from the available information to describe the hypothetical representative systems. The values chosen are shown in TABLE 7.

Using these characteristic values, the algorithm applies the modification factors to the historic baseline cost data. Representative cost projections are obtained by using the following equation:

$$R_x = S_R \cdot M_x \cdot P_x(H) \cdot P_x(L)$$

where R_x = Representative baseline annual direct labor cost for phase x

  (x = 1, 2, 3, ...8)

  S_R = Cost/Manmonth for the skill level of the representative system.

  M_x = Initial baseline annual manmonths required for phase x

  $P_x(H)$ = Function of modification factors whose overall effect is to increase costs for phase x

  $P_x(L)$ = Function of modification factors whose overall effect is to decrease costs for phase x

As shown by the equation above, the representative costs are computed independently for each phase (requirements review (x=1), design (x=2), development (x=3), integration (x=4), T&E (x=5), documentation (x=6), reproduction/installation (x=7), and support software (x=8)). The algorithm starts with the historic manmonths (M_x), modifies this figure based on the

TABLE 7
CHARACTERISTICS OF THE REPRESENTATIVE SYSTEMS

CHARACTERISTIC	NAVIGATION WEAPON DELIVERY OFP	JAMMER EW	FIRE CONTROL OFP	RECEIVER EW	INTEGRATED SYS EW	NAVIGATION FIRE CONTROL WEAPON DELIVERY OFP	COMMAND & CONTROL CE
FIRST YEAR OF SUPPORT	1977	1979	1978	1978	1979	1978	1978
LINES OF CODE (K)	16	15	28	16	36	32	150
LANGUAGE	1	1	1	1	1	1	3
% MEMORY FILL	90	90	90	80	75	90	80
% TIMING FILL	80	90	90	90	90	90	85
DEV V&V RATING	2	2	3	2	2	2	2
DESIGN RATING	2	2	2	2	2	2	2
IMPLEM RATING	3	2	2	2	2	2	2
MNT DOC RATING	2	2	2	2	2	2	2
REPRODUCTION MEDIUM	3	1	3	2	1	1	3
AIRCRAFT TYPE	3	3	3	3	2	3	4
NO. FIELDED SYS	500	600	700	950	250	500	100
COMPLEXITY	4	3	4	3	4	4	3
RATE OF CHANGE	3	4	4	3	4	4	3
SKILL LEVEL MIX	3	3	4	3	3	4	3
CHANGE EFFICIENCY (%)	65	50	60	50	50	65	75
DIRECT SUPP'T EQUIP'T ($ MIL)							
HARDWARE(1981)	2.737	1.261	2.667	5.571	4.000	3.070	3.041
SOFTWARE(1981)	1.263	5.739	1.333	3.429	4.000	.930	3.959
EXPECTED SYSTEM LIFE (Years)	20	20	20	20	20	20	20
BLOCK CHANGE LENGTH (Months)	12	12	12	12	12	12	12
SUPPORT SOFTWARE MAINTENANCE	1	1	1	1	2	1	1
% CONTRACTOR	0	0	0	0	0	0	0
LOCATION OF CONTRACTOR	0	0	0	0	0	0	0

NOTE: SEE FIGURE 2 FOR THE MEANING OF EACH NUMERICAL VALUE

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cumulative change in the characteristic values ($P_x(H)$ and $P_x(L)$), and finally converts manmonths to dollars. This is accomplished by multiplying by the cost per manmonth for the representative skill level (S_R). Another way of viewing these computations is illustrated in FIGURE 10.

The historic manmonths are provided by APPENDIX H; they are also repeated in TABLE 8 for the reader's convenience. The possible values for S_R are provided on page 51 above. $P_x(L)$ and $P_x(H)$, however, require further explanation.

The functions $P_x(L)$ and $P_x(H)$ are derived from the modification factors. They are used to quantify the impact on manmonths directly caused by a change in one or more system characteristics. These changes are measured in relative rather than absolute terms. Thus, the modification factors are always a ratio of computations which result in the relative impact on manmonths of changing a characteristic from one value to another.

For example, if the language is FORTRAN for the historic system and a structured higher order language for the representative system, then the separate impact on manmonths for program development is computed as follows:

$$.62/.67 = .925$$

The numbers .62 and .67 are taken right out of TABLE 4 under language. Manmonths would be expected to decrease by 7.5%. Thus, the ratio of modification factors for any given characteristic is the relative impact on manmonths from changing the value of that characteristic from the historical value to the representative value.

$P_x(H)$ accounts for the combined effect of those factors which increase costs. $P_x(L)$ accounts for those which decrease costs. The derivation of $P_x(H)$ and $P_x(L)$ is explained in the following paragraphs.

FIGURE 10
COMPUTION OF LABOR COSTS FOR THE REPRESENTATIVE SYSTEM

PHASE (X)	HISTORICAL MANMONTHS	X	COST PER MANMONTH	X	ADJUSTMENT FACTORS	=	REPRESENTATIVE LABOR COST
REQUIREMENTS REVIEW (1)	M_1		S_R		$P_1(L) \times P_1(H)$		R_1
DESIGN (2)	M_2		S_R		$P_2(L) \times P_2(H)$		R_2
DEVELOPMENT (3)	M_3		S_R		$P_3(L) \times P_3(H)$		R_3
INTEGRATION (4)	M_4		S_R		$P_4(L) \times P_4(H)$		R_4
TEST & EVALUATION (5)	M_5		S_R		$P_5(L) \times P_5(H)$		R_5
DOCUMENTATION (6)	M_6		S_R		$P_6(L) \times P_6(H)$		R_6
REPRO/INSTALLATION (7)	M_7		S_R		$P_7(L) \times P_7(H)$		R_7
SUPPORT SOFTWARE (8)	M_8		S_R		$P_8(L) \times P_8(H)$		R_8

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TABLE 8
SUMMARY OF MANMONTHS BY LABOR CATEGORY FOR EACH APPLICATION TYPE
(HISTORICAL DATA)

PHASE	F-111F NAVIGATION WEAPON DELIVERY OFP		ALQ-131 JAMMER EW		F-16 FCC FIRE CONTROL OFP		ALR-62 RECEIVER EW		APR-38 INTEGRATED SYS EW		A-7 NAVIGATION FIRE CONTROL WEAPON DELIVERY OFP		E-3A COMMAND & CONTROL CE	
	MM	CAT	MM	CAT	MM	CAT	MM	CAT	MM	CAT	MM	CAT	MM	CAT
1. REQUIREMENTS REVIEW	1.5	GS11	2	GS12	6	GS11	2	GS12	2	GS9	5	GS12	2	GS12
	.1	GS13	1	GS13	18	GS12			2	GS11	5	GS13	1	0-3
	1.5	0-3			1	GS13			3	GS12	5	0-4	1	0-4
	5.9	CONTR.									2	CONTR.		
2. DESIGN	1.7	GS11	4	GS12	4	GS11	2	GS7	3	GS9	6	GS12	7	GS12
	.8	0-3	1	GS13	10	GS12	6	GS12	3	GS11	6	GS13	3	0-1
	11.0	CONTR.			1	GS13	4	CONTR.	6	GS12	2	CONTR.	5	0-3
3. DEVELOPMENT	1.8	GS11	4	GS12	2	GS11	2	GS7	2	GS9	2	GS12	3	0-1
	.7	0-3	1	GS13	10	GS12	6	GS12	3	GS11	5	GS13	12	GS12
	11.0	CONTR.			1	GS13	4	CONTR.	5	GS12	4	CONTR.	15	0-1
													4	0-2
													6	0-3
4. INTEGRATION	1.5	GS11	4	GS12	2	GS11	2	GS7	2	GS9	2	GS12	3	0-1
	1.5	0-3	1	GS13	6	GS12	4	GS12	4	GS11	2	GS13	2	0-2
	17.1	CONTR.			1	GS13	2	CONTR.	6	GS12	2	CONTR.	1	0-4
5. T&E	3.0	GS11	12	GS12	2	GS11	2	GS7	6	GS9	5	GS9	1	GS11
	.1	GS13	1	GS13	16	GS12	2	GS12	3	GS11	5	GS12	1	GS12
	3.0	0-3			1	GS13	1	CONTR.	9	GS12	5	GS13	2	0-1
	18.9	CONTR.							4	0-1	3	0-1	3	0-3
											5	0-4		
6. DOCUMENTATION	2.0	GS11	10	GS12	1	GS9	2	GS7	2	GS9	2	GS12	2	GS9
	2.0	0-3	1	GS13	4	GS11	2	GS12	9	GS11	2	GS13	3	0-1
	10.0	CONTR.			6	GS12	1	CONTR.			6	CONTR.		
					1	GS13								
7. REPRO/INSTALLATION	3.0	GS11	2	GS12	1	GS9	1	GS7			2	GS9	3	0-1
	3.0	0-3			1	GS12								
8. SUPPORT SOFTWARE	2.0	GS11	3	GS12	6	GS11	4	GS7			4	GS9	15	GS12
	2.0	0-3			30	GS12	6	GS12			18	GS12	10	0-1
	20.3	CONTR.			1	GS13					2	GS13	4	0-3

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Assume that $F_{i,x}$ is defined to be the relative impact on manmonths in phase x caused by modifying system characteristic i. (i refers to any of the sixteen modification factors. See TABLES 3 and 4 above.) $F_{i,x}$ is the ratio of the modification function's value after the change, divided by the modification function's value before the change. Written algebraically,

$$F_{i,x} = A_{i,x}/B_{i,x}$$

where $A_{i,x}$ = The value of each modification factor i for phase x using the characteristic value of the representative system

$B_{i,x}$ = The value for each modification factor i for phase x using the characteristic value of the historic system.

For example, if lines of code is 30K for the representative system and 24K for the historical system, the ratio of the modification factors for the first two phases (requirements reviews and design) is:

$$F_{1,1} = \frac{.0255\,(30) + .587}{.0255\,(24) + .587} = 1.128$$

$$F_{1,2} = \frac{.239\,(30)^{.539}}{.239\,(24)^{.539}} = 1.128$$

Note that the equations above are from TABLE 3 under lines of code. Thus there are 16 modification factor ratios computed, one for each characteristic, for each of the 8 phases. The resulting matrix follows.

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	Requirements Review	Design Rating	Development Rating				Support Software
Lines of Code	$F_{1,1}$	$F_{1,2}$	$F_{1,3}$	.	.	.	$F_{1,8}$
% Memory Fill	$F_{2,1}$	$F_{2,2}$	$F_{2,3}$	.	.	.	$F_{2,8}$
% Timing Fill	$F_{3,1}$	$F_{3,2}$	$F_{3,3}$	.	.	.	$F_{3,8}$
.		.	.	. .	.	. .	
.		.	.	. .	.	. .	
.		.	.	. .	.	. .	
Work Efficiency	$F_{16,1}$	$F_{16,2}$	$F_{16,3}$	.	.	.	$F_{16,8}$

Once these ratios are computed they are positioned according to ascending order within each phase. If j represents the position number (j = 1, 2, 3 ... 16), then a new vector $F_{i,x,j}$ will be formed for each phase x. This is illustrated below:

$$F_{i,x,1} \quad F_{i,x,2} \quad F_{i,x,3} \quad \cdots \quad F_{i,x,16}$$

For example, suppose all of the modification factor ratios for requirements review are computed. The vector would be rearranged in ascending order. This is illustrated below.

i	Characteristic	Computed Modification Factor Ratios	i	Rearranged Modification Factor Ratios	j
1	Lines of Code	1.536	15	.716	1
2	% Memory Fill	1.000	8	.781	2
3	% Timing Fill	.976	9	.816	3
4	% Work Contractor	1.237	16	.875	4
5	Year of Support	.901	5	.901	5
6	No. Fielded Systems	.978	12	.910	6
7	Change Efficiency	1.372	3	.976	7
8	Language	.781	6	.978	8
9	Dev V&V Rating	.816	13	.996	9
10	Program Design Rating	1.213	2	1.000	10
11	Implementation Rating	1.210	11	1.210	11
12	Init Documentation	.910	10	1.213	12
13	Type of Aircraft	.996	4	1.237	13
14	Complexity	2.138	7	1.372	14
15	Rate of Change	.716	1	1.536	15
16	Work Efficiency	.875	14	2.138	16

The functions $P_x(H)$ and $P_x(L)$ can now be computed from the resulting vector. The formulas for $P_x(H)$ and $P_x(L)$ are shown below:

$$P_x(H) = \prod_{j=1}^{S} ((F_{i,x,j} - 1)(W_j) + 1) \qquad (3)$$

$$P_x(L) = \prod_{j=1}^{T} \frac{1}{(\frac{1}{F_{i,x,j}} - 1)(W_j) + 1} \qquad (4)$$

In the two equations above, W_j is a vector representing various weights applied to the separate impacts of each characteristic. Since the independent impacts of each of the 16 system characteristics can be expected to interact with one another, an additional smoothing algorithm is necessary. This additional smoothing algorithm reduces the compounding effect of two or more factors which affect costs in the same direction.

It should be noted that the effect of incorporating the weighting factors materially affects cost projections only under certain conditions. When two or more characteristic values change such that the separate cost impacts are considerable and in the same direction, the weighting factors will tend to reduce the overall impact on the cost projections. In other words, the combined effect of changing characteristic values will be less than if the individual effects are treated separately and simply added to one another.

The values for W are determined judgmentally based on actual data and expert intuition. The actual values are shown below:

j	W_j
1	1.0
2	.667
3	.50
4	.40
5	.30
6	.20
7	.10
8	.05

S and T in Equations (3) and (4), respectively, are values of j. S represents the number of modification factor ratios that is greater than unity and is constrained to be 8 or less. T is the number of ratios less than unity and is also constrained to be 8 or less. Thus, if more than eight modification factors tend to change costs in the same direction, only the eight with the greatest individual impacts will be included in the computations. The others will be ignored.

To illustrate, the computations of $P_x(L)$ and $P_x(H)$ are shown below for the example previously begun.

$$P_1(H) = \prod_{j=1}^{6} ((F_{1,i,j} - 1)(W_j) + 1)$$

$$P_1(H) = 2.138 \cdot ((1.536-1)(.667)+1) \cdot ((1.372-1)(.50)+1) \cdot ((1.237-1)(.40)+1)$$
$$\cdot ((1.213-1)(.30)-1) \cdot ((1.210-1)(.20)-1)$$

$$P_1(H) = 4.1777$$

$$P_1(L) = \prod_{j=1}^{8} \frac{1}{(\frac{1}{F_{1,i,j}} - 1)(W_j) + 1}$$

$$P_1(L) = .716 \cdot \frac{1}{(\frac{1}{.781} - 1)(.667) + 1} \cdot \frac{1}{(\frac{1}{.816} - 1)(.50) + 1}$$

$$\cdot \frac{1}{(\frac{1}{.875} - 1)(.40) + 1} \cdot \frac{1}{(\frac{1}{.901} - 1)(.30) + 1} \cdot \frac{1}{(\frac{1}{.910} - 1)(.20) + 1}$$

$$\cdot \frac{1}{(\frac{1}{.976} - 1)(.10) + 1} \cdot \frac{1}{(\frac{1}{.996} - 1)(.05) + 1}$$

$$P_1(L) = .4855$$

Thus, in this example the overall impact on requirements review manmonths caused by changes in characteristic values between the representative and historical system is:

$$P_1(L) \cdot P_1(H) = .4855 \cdot 4.1777$$
$$P_1(L) \cdot P_1(H) = 2.0283$$

That is, due to changes in the characteristics between the historical and representative systems, the number of manmonths required for requirements review can be expected to be more than double in this example.

Once the direct labor costs are estimated, indirect labor, direct support equipment, and general support equipment costs can be estimated. This is accomplished by applying the normalization factors and the relationships shown in FIGURE 11. APPENDIX I provides the specific computations.

A representative baseline is derived from each of the seven historical baselines. The computations are based on the changes in characteristic values between the representative and historical systems, using the modification factors and the algorithm described above. The results from this analysis are provided in APPENDIX J. The representative characteristics which these costs reflect are shown above in TABLE 7.

4.5.3 Cost Projections

Once the representative baseline systems are derived, the model is ready to project cost estimates given a new set of characteristics. This set is to be offered by the individual desiring to estimate future costs for various possible system configurations. With this information, the user will be able to reliably compare the costs for the many configuration options which exist during the conceptual phase.

The key to this portion of the algorithm is the set of new characteristic values. As these values are altered from the representative values, the modification factors will be used in precisely the same way as before. Only this time, the representative system characteristics and costs will be the starting point. Applying the modifications as before, direct labor costs are estimated by using the following formula:

FIGURE 11
ESTIMATION OF OTHER COST SEGMENTS

SUPERVISION
ADMINISTRATION } = F (DIRECT LABOR MANMONTHS)

FACILITY/UTILITIES
FURNISHINGS
MATERIALS/SUPPLIES } = F (NO. OF PEOPLE)
COMPUTERS/TERMINALS

NO. OF PEOPLE = F (DIRECT LABOR MANMONTHS, INDIRECT LABOR MANMONTHS, BLOCK CHANGE LENGTH)

EMBEDDED COMPUTER SYSTEM/INTERFACES
LAB EQUIPMENT } = THROUGHPUT VALUES
SIMULATOR
SOFTWARE

TEST AIRCRAFT/TIME = F (DIRECT T&E)

REPRODUCTION = F (NO. OF FIELDED SYSTEMS, REPRODUCTION MEDIUM, PROGRAM SIZE)

MAINTENANCE = F (HARDWARE COST)

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$$L = \sum_{X = 1}^{8} \frac{R_x \cdot S_p}{S_R} \cdot P_x(H) \cdot P_x(L)$$

where L =   Annual total direct labor cost for the system specified by the operator

R_x =   Annual direct labor cost for phase x for the representative system

S_p =   Cost/manmomth for the derived skill level of the proposed system

S_R =   Cost/manmonth for the skill level of the representative system

$P_x(H)$ =   Function of modification factors whose overall effect is to increase costs for phase x

$P_x(L)$ =   Function of modification factors whose overall effect is to decrease costs for phase x

Another way of viewing this equation is provided in FIGURE 12. In this equation, the functions $P_x(H)$ and $P_x(L)$ are computed the same way as for the representative baseline costs, except that the modification factors are applied to the representative costs rather than the historical costs. In the equation, R_x/S_R is the number of representative manmonths. Thus, multiplying by $P_x(H)$ and $P_x(L)$ results in the number of manmonths required for the proposed system. Multipying again by S_p converts the numbers of manmonths to a cost figure.

If is assumed as before that $F_{i,x}$ is defined to be the relative impact on manmonths in phase x caused by modifying system characteristic i, then $F_{i,x}$ is computed as follows:

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FIGURE 12
COMPUTATION OF LABOR COSTS FOR THE PROPOSED SYSTEM

PHASE (X)	REPRESENTATIVE MANMONTHS	X	COST PER MANMONTH	X	ADJUSTMENT FACTORS	=	PROPOSED SYSTEM LABOR COST
REQUIREMENTS REVIEW (1)	R_1/S_R		S_P		$P_1(L) \times P_1(H)$		
DESIGN (2)	R_2/S_R		S_P		$P_2(L) \times P_2(H)$		
DEVELOPMENT (3)	R_3/S_R		S_P		$P_3(L) \times P_3(H)$		
INTEGRATION (4)	R_4/S_R		S_P		$P_4(L) \times P_4(H)$		
TEST & EVALUATION (5)	R_5/S_R		S_P		$P_5(L) \times P_5(H)$		
DOCUMENTATION (6)	R_6/S_R		S_P		$P_6(L) \times P_6(H)$		
REPRO/INSTALLATION (7)	R_7/S_R		S_P		$P_7(L) \times P_7(H)$		
SUPPORT SOFTWARE (8)	R_8/S_R		S_P		$P_8(L) \times P_8(H)$		
TOTAL							L

$$F_{i,x} = (C_{i,x}/A_{i,x})$$

where $C_{i,x}$ =   The value for each modification factor i for phase x

using the characteristics of the proposed system.

$A_{i,x}$ =   The value for each modification factor i for phase x

using the characteristics of the representative system.

Substituting $C_{i,x}$ for $A_{i,x}$ and $A_{i,x}$ for $B_{i,x}$, $P_x(H)$ and $P_x(L)$ are computed in precisely the same fashion as described in the previous section.

Finally, the labor costs are computed for each of the eight work phases and summed. The total, L in the equation, represents the total annual cost for direct labor. In order to breakdown this total into the eight phases, SYSCON determined that a general methodology would be superior to simply accepting the previously computed subtotals. The reason for this is twofold; first, the historical breakdown of labor costs by phase from which the projections are based may not be representative of a typical system. Second, because of the purpose for which the ASSCM is designed, a general breakout of labor costs is superior. This allows the cost for two or more proposed systems to be more consistently compared. .

As a result, SYSCON chose percentages which, when applied to the labor cost total, could be used to estimate the labor cost by phase. These percentages are derived from the historical data available and are deemed most reasonable for all system types. See TABLE 9. The derivation of these figures is shown in APPENDIX K. Thus, to estimate the costs by phase, the percentages are simply multiplied by the projected direct labor cost total.

For other cost elements within the WBS, the normalization factors are applied in the same fashion as for the representative system. See FIGURE 10 above and APPENDIX I for the methodology.

TABLE 9
ALLOCATION FACTORS

DIRECT LABOR

PHASE	% OF TOTAL DIRECT MANMONTHS	
	SUPPORT SOFTWARE	NO SUPPORT SOFTWARE
REQUIREMENTS REVIEW	9	11
DESIGN	13	17
DEVELOPMENT	16	21
INTEGRATION	10	13
T & E	16	21
DOCUMENTATION	11	14
REPRO/INSTALLATION	2	3
SUPPORT SOFTWARE	23	0

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5 COMPUTERIZATION

The computerization phase first involved reviewing the available software and hardware of the systems on which the ASSCM would be installed. This was done to determine if there were any constraints that could impact the program's design specifications. Initial development of the program was done on SYSCON's HP-3000, and this also was taken into consideration. Using the results of the review, a method of automating the model algorithm was developed that would satisfy these requirements. This section addresses the computerization procedures taken to design and develop the ASSCM computer program. For a more detailed discussion of the computer program, see the Computer Program Production Specification (Applicable Document No. 12).

5.1 Design

The purpose of the design phase is to develop a modular approach in transferring the model algorithm into a computer program. A three step process is used as a basis for deriving this modularity.

USER INPUTS ⟶ COMPUTATIONS ⟶ OUTPUT
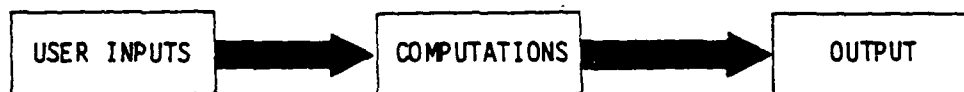
From this point the various processes are further broken down into specific subroutines. Each subroutine is defined on the basis of the task it is designed to perform. This results in eleven specific subroutines which are illustrated in FIGURE 13.

5.1.1 Model Executive (MODEXEC)

The model executive is the first and last subroutine executed and provides overall control for the program. Its main function is to access each of the other 10 subroutines to perform its task.

FIGURE 13

Top Level Program Flow

	MODEXEC	
	Model Executive	

```
MANAGE          OPTION          NORMAL          DLCOST          WROUT
Account         Process         Normalize       Compute Direct  Write
Management      Options         Data            Cost            Out Results

INSTRT          INIT            BASLIN          ADJUST          ALOCAT
Provide         Initialize      Retrieve        Adjust          Allocate
Instruction     Variables       Baseline        Data            All Costs
```
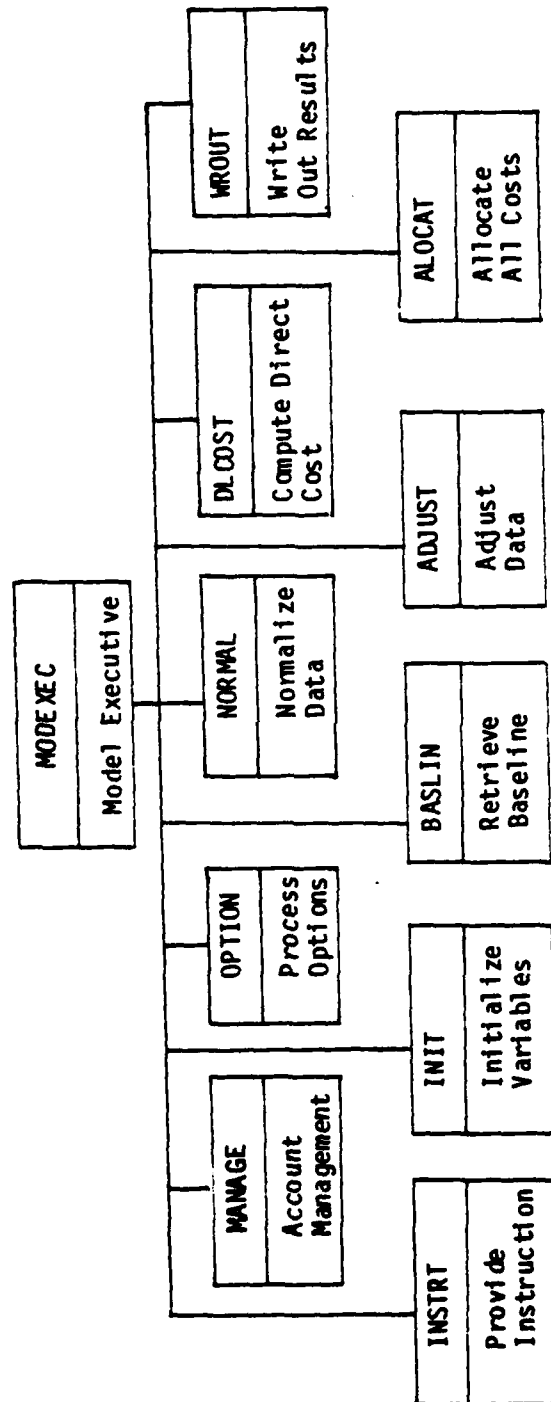
5.1.2 Instruction Subroutine (INSTRT)

The instruction subroutine allows the operator the option of viewing the instructions. If he chooses to do so, a file containing the instructions on the model and its use is printed out to the user's terminal.

5.1.3 Account Management Subroutine (MANAGE)

The account management subroutine provides the user with the opportunity to create a personal account by supplying his own password. This allows the user to create and save his own input files within this account. Only by providing this password at the beginning of a session can these files be recalled and/or deleted during a future run.

5.1.4 Initialization Subroutine (INIT)

This subroutine allows the user to choose one of the seven baseline systems for which costs are to be projected. The external files containing the appropriate historical data are read in and all necessary variables are initialized based on the system chosen.

5.1.5 User Option Subroutine (OPTION)

The user option subroutine allows the user to supply interactively three types of information. The user may:

- input the appropriate information that describes the proposed embedded computer system software for which software maintenance costs are to be projected
- view and/or modify any of the normalization factors
- choose the desired output format for the ensuing cost projection.

5.1.6 Database Retrieval Subroutine (BASLIN)

This subroutine reads in the data for the historic direct labor manmonths from an external file and initializes the appropriate variables according to the system chosen in the initialization subroutine.

5.1.7 Normalization Subroutine (NORMAL)

The normalization subroutine derives all costs for the historical system using the historic direct labor manmonths and the normalization factors. This results in the historic baseline data for the type of system and application chosen by the user.

5.1.8 Adjustments Subroutine (ADJUST)

This subroutine substitutes the characteric values of the historical and repesentative systems into the modification factors. The modification ratios are then computed and applied to the historic direct labor manmonths by phase to derive the representative baseline direct labor manmonths by phase. Lastly, all other costs for the representative system are derived using the direct labor manmonths and the normalization factors.

5.1.9 Direct Labor Cost Subroutine (DLCOST)

The direct labor cost subroutine substitutes the characteristic values of the representative and proposed systems into the modification factors. This second set of modification ratios is computed and applied to the representative direct labor manmonths by phase and summed to derive a total direct labor cost for the proposed system.

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5.1.10 Cost Allocation Subroutine (ALOCAT)

This subroutine utilizes the total annual direct labor cost projection and cost allocation factors to determine a breakdown of the direct labor costs by phase. In addition, this subroutine derives all other cost elements associated with maintaining the software.

5.1.11 Write Out Subroutine (WROUT)

This subroutine outputs to the user the cost breakdown for the proposed system according to the output formats selected previously by the user.

5.2 Development

The ASSCM computer program was developed over a period of seven months on SYSCON's HP-3000 and VAX 11/780. The program is written in ANSI Standard FORTRAN for interactive use on the ASD Cyber 175 and the Avionics Laboratory VAX 11/780. Two separate programs exist with the only differences being the result of peculiarities present within the respective machines.

5.2.1 Coding

The ASSCM is developed in accordance with the requirements specified in the Software Design Specification (See Applicable Document No. 7). A hierarchical structure is used to provide a cohesive software system which facilitates easy expansion and modification of the model. This also provides for portability of the implemented software between the VAX 11/780 and the Cyber 175 computer systems. The coding of the eleven subroutines and six files was done in four separate stages, each with a well-defined objective. See TABLE 10 for a summary of these four stages.

TABLE 10
CODING STAGES

STAGE	CODING REQUIRED	OBJECTIVE
1	"DATAFL1", "DATAFL2", "DATAFL3", "DATAFL4", MODEXEC, INIT, BASLIN, NORMAL, WROUT	CREATE DATA FILES, READ IN THE FILES TO THE ASSCM COMPUTER PROGRAM AND CALCULATE ALL COSTS ASSOCIATED WITH THE HISTORICAL SYSTEMS.
2	ADJUST, WROUT	DERIVE MODIFICATION RATIOS, APPLY TO HISTORICAL DIRECT LABOR MANMONTHS TO DERIVE REPRESENTATIVE DIRECT LABOR MANMONTHS, AND COMPUTE ALL OTHER COSTS ASSOCIATED WITH THE REPRESENTATIVE SYSTEM.
3	OPTION, DLCOST ALOCAT, WROUT	PROVIDE USER OPPORTUNITY TO DESCRIBE PROPOSED SYSTEM, DERIVE MODIFICATION RATIOS, APPLY TO REPRESENTATIVE DIRECT LABOR MANMONTHS, TO DERIVE PROPOSED DIRECT LABOR MANMONTHS, AND COMPUTE ALL OTHER COSTS ASSOCIATED WITH THE PROPOSED SYSTEM.
4	INSTRT, "TEXT", MANAGE, "FILES", OPTION, WROUT	FINALIZE CODING OF ASSCM BY INCLUDING ROUTINES TO FACILITATE INTERACTIVE USE.

NOTE: QUOTES INDICATE EXTERNAL FILES

5.2.2 Integration and Testing

As each stage of coding was completed, top-down integrated testing was performed to ensure conformity with the Software Design Specification and to demonstrate the completion of development milestones. There were four such stages, each successfully completed to insure that the model executed properly.

The first stage of integration consisted of creating an external data base for the four permanent data files. These files contain the historical characteristics, representative characteristics, the normalization factors, and the historic direct labor manmonths by phase. The objective of this first stage was to read in the files and correctly compute the historical baseline of costs for each of the seven systems.

Like the first stage, the second stage did not require any user input. The objective of this stage was to derive the representative baseline data by applying the modification factors to the historical baseline. All computations performed by the model were done externally to check for accuracy.

Stage three utilized information provided by the user. Using the characteristic values of a proposed system configuration, the model computed all the projected costs. This is accomplished by applying modification factors to the representative baseline data. The objective here was to confirm that all of the cost information derived was an accurate reflection of the user-inputted characteristics. The results were also compared to computations performed outside the model.

The fourth stage did not involve data manipulation of any kind. The user interface was refined by adding a subroutine to print instructions from an external file. In addition, another subroutine was incorporated into the model to allow the user to create, save, and delete his own input files.

6   VALIDATION

6.1 Summary

The development of a cost estimating model cannot be successfully concluded unless there is some way to test how good and how reliable the estimates are. Therefore, it is necessary to evaluate the resulting cost projections to make sure that they are not only plausible, but reasonable as well. Moreover, cost projections must be consistent with the known facts as well as with common sense.

6.2 Methodology

The validation procedure requires data from existing systems that were not used in the development of the ASSCM cost estimating algorithm. This is necessary to insure that the cost projections are derived independently from the existing data to which the projections are to be compared. To accomplish this, SYSCON conducted an exhaustive search to complete its data base as best it could. This resulted in complete cost and characteristic information for two systems and incomplete cost information for an additional system. These are listed below:

System	Type	Application	Cost Data	Characteristic Data
ALQ-155	EW	Integrated System	Complete	Complete
FB-111A	OFP	Navigation, Weapon Delivery	Complete	Complete
ALR-69	EW	Receiver	Incomplete	Complete

In order to facilitate the validation of the ASSCM it is necessary to compare actual costs with those projected by the model. To accomplish this, SYSCON inputted the descriptive characteristics for the three systems listed

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above and allowed the model to project the annual software maintenance costs for fiscal year 1981. If the discrepancies between the actual and estimated costs are small or can be reasonably explained, then one can conclude that the model is valid.

By making these comparisons, SYSCON obtained encouraging results. A segment by segment comparison indicated few major discrepancies. Where significant discrepancies did exist, plausible explanations concerning the historic data were readily apparent.

6.3 Validation Results

A summary of the model's projections versus the actual costs is shown below for the major cost segments.

System	Actual Cost			Predicted Cost			Percent Deviation		
	Total	Labor	Support	Total	Labor	Support	Total	Labor	Support
ALQ-155	1,862,302	200,509	1,661,793	2,012,825	147,228	1,865,597	+8.1	-26.6	+12.3
FB-111A	8,870,723	280,968	8,589,755	9,104,983	368,501	8,736,482	+2.6	+31.2	+1.7
ALR-69	?	?	2,754,286	2,686,117	313,268	2,372,849	?	?	+16.1

As discussed in the Validation Report (Applicable Document No. 13), all of the major differences between actual and estimated costs are explained. These explanations are summarized in FIGURE 14.

It should be pointed out that two important changes were incorporated into two modification factors and one normalization factor directly as a result of the validation comparisons. That is, the validation process uncovered previous errors that became readily apparent only after a comparison of the actual and projected costs was made. This led to the reduction of impact on costs for low percentages of percent memory fill and percent timing

FIGURE 14

REASONS FOR MAJOR
DISCREPANCIES BETWEEN HISTORIC AND
PROJECTED COSTS

System	Cost Segment	Explanation
ALQ-155	Direct Labor (Support Software)	Actual costs exhibited an abnormally high proportion of time to maintain the support software in this second block change
	Support Equipment (Test Aircraft/Time)	No actual costs were expended for this cost segment. This is highly irregular
FB-111A	Direct Labor (Development, Integration)	Model may overstate costs when percentage of work performed by contractors is high; implementation structure rating may be in error
	Support Equipment (Test Aircraft/Time)	Actual costs appear to be low when compared to costs experienced during previous block changes
ALR-69	Support Equipment (Test Aircraft/Time)	Estimate is computed directly from the direct labor T&E estimate which was high. Estimates assume all work performed organically when at least two phases of work were performed by contractors. Model is not designed to handle this situation
	Support Equipmen' (Reproduction)	Actual work was performed by contractors. Model is not designed to handle this situation.

fill (See footnote 1 in TABLE 3) and the addition of a time-dependent K for the PROM's medium factor (see footnote 1 in TABLE 1-D).

In summary, SYSCON concludes that to the extent possible, the ASSCM has shown that it provides reasonable, accurate cost projections for existing systems. Part of this success is due to the support costs being known. During the conceptual phase, where these costs are not known the model may not be expected to be as accurate. SYSCON believes though, and has demonstrated, that the ASSCM can be used with confidence to project and support cost estimates for maintaining the software on proposed avionics systems in the future.
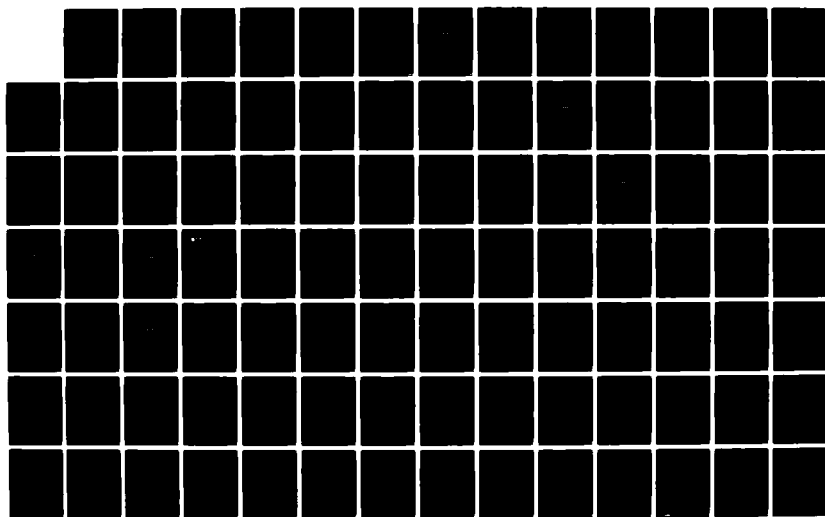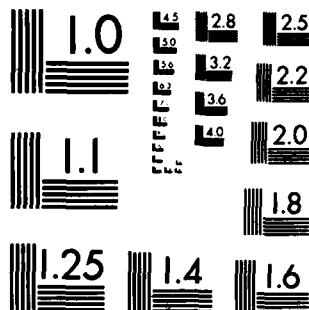
MICROCOPY RESOLUTION TEST CHART

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7 INSTALLATION AND TRAINING

7.1 Installation

The ASSCM computer program was successfully installed on the VAX 11/780 at Wright-Patterson Air Force Base. This task was simplified since final development of the model was completed on SYSCON's VAX 11/780. Once the program was compiled and executing correctly on the VAX, a separate tape was made for installation on the ASD Cyber 175. Once installed, some modifications were made to the program source code to allow the ASSCM to be compiled and executed correctly on the Cyber 175 system. Thus, one version is currently being maintained for both of the Air Force's systems. For a summary of the differences between the two versions, refer to the Computer Program Product Specification. (Applicable Document No. 12)

7.2 Training

A one-day training course was given at Wright-Patterson Air Force Base for all necessary Air Force and DOD personnel. At that time an oral presentation was given and the training materials and User's Manual were delivered. The training course covered model description, user interface, model algorithm, and internal computations performed by the ASSCM computer program.

8   FUTURE CONSIDERATIONS

This section details four areas where SYSCON feels that additional effort may be expended by the Air Force to expand or enhance the capabilities of the ASSCM. The four suggested areas are listed below.

- Development of Data Collection Techniques
- Collection of Additional Data
- Addition of New Systems and System Applications to the Model
- Modification of the Model To Support Other Requirements

The first two areas deal with the collection of cost data to support the model. The last two are concerned with adding capabilities to the model to support additional Air Force requirements. Each of these areas are discussed in the following paragraphs.

8.1 Development of Data Collection Techniques

The first year of the ASSCM developent effort centered around the design of the ASSCM algorithm and the collection of cost data from the ALC's to support the algorithm. It was determined during the initial data collection trip that little data was available. When data was available, it was frequently poorly organized and not readily useable. (See APPENDIX A.)

SYSCON suggests that the Air Force support an effort to develop a cost and tracking methodology which may be applied across all ALC's. This methodology must include but not be limited to:

- identification of all data to be collected
- identification of sources for this data
- providing standard reporting and data collection forms
- identification of filing requirements
- identification of audit requirements to insure timely and accurate data collection.

This methodology is just a first step to insure pertinent, reliable, and accurate information for future model developments and accurate cost tracking. The time spent by the ALC personnel to collect, correlate and report this data will be more than offset by their increased visibility into the costs associated with the software support area.

8.2 Collection of Additional Data

The model developed and implemented by SYSCON is a viable means to estimate costs associated with avionics software support. As with any model, however, the accuracy of the model is only as good as the data which supports the model. SYSCON has endeavored to make the model flexible and maintainable. To meet this end, all cost data used to support the model can be easily updated to allow for the use of newer, more accurate cost information.

SYSCON feels that the Air Force should review the costs associated with the software support area at least every two years and incorporate any additional information into the model. This will insure that cost projections estimated by the model will be based on the most current information.

This effort may be best organized if it is tied with the development of data collection techniques discussed in the previous section.

8.3 Addition of New Systems and System Applications

The development of the ASSCM, as specificed in the government statement of work, does not address the software support cost associated with Automatic Test Equipment (ATE) and Aircrew Training Devices (ATD). The model, as designed, could easily be updated to estimate costs for these systems as well. Moreover, additional applications of CE, EW, and OFP systems may be

added to increase the capabilities of the model's projections to cover these new areas. The effort in all cases would require data collection, model modification, testing, validation, and documentation.

8.4 Modification of the Model

As with many model developments, the ASSCM is designed to support a specific requirement. The methodology employed, however, is well suited to many applications where the volume of data is inadequate to support traditional cost estimating techniques. The applicability of the model methodology must be assessed on a case by case basis. The unique algorithm developed for the ASSCM is appropriate when the need arises to project costs and very little data exists to support the projections. The algorithm utilizes the historic data available plus the judgment of cost experts. Moreover, the methodology breaks down each individual cost estimate to a much more manageable degree and then sums up all of the pieces to arrive at a final estimate.

The ASSCM, as developed by SYSCON, might also support additional requirements in the software support area. Requirements of other labs and divisions within ASD, as well as requirements of AFLC, might be addressed through minor changes in the model's output.

APPENDICES

APPENDIX
A

DATA COLLECTIONS PROBLEMS

Direct Labor

Total manhours required to complete a block change appear to be
available from Form 75. This is the only source of documentation.
It will be difficult, however, to match manhours with the cost per
manhour for the following reasons: 1) people are not necessarily
dedicated to one change block or system; 2) contractors perform part
of the work for which manhours may or may not be available; 3) new
hires and resignations are common causing turnover; 4) the nature
of the work causes training to be long and tedious, resulting in a
high variation of productivity; 5) Form 75 data represent only an
estimate of hours; 6) the cost per manhour or GS grade of a worker
does not necessarily indicate the degree of productivity; and 7) man-
hours are not necessarily broken out by task as desired according
to the WBS.

It should also be noted that the number of manhours and the cost
per manhour reported might reflect the availability rather than the
requirement for people. This is because the work involved is exceeding-
ly specialized, and manpower needs cannot be met under optimal conditions.

In the opinion of several Air Force personnel, manhours by task
could be obtained along with their cost from available Government records
(other than Form 75) and interviews. The effort necessary to complete
this research in order to recreate the manpower expended would be
tedious, perhaps taking as long as a manmonth for each system. Such an
attempt was not made during the data collection trip.

Indirect Labor

Indirect labor costs include supervision and administration. These
hours are not normally broken out by system so no data is available. It
does seem possible, however, that an estimate could be made based on the
amount of direct labor spent on a particular block change. Perhaps
only a percentage of the direct labor cost is all that is necessary.
In any event, the collection of actual manhours and costs for each system
does not seem possible given a reasonable time frame to collect this data.

Direct Support Equipment

Direct support equipment varies tremendously among systems. Thus,
the estimation of costs for this equipment is difficult, especially because
of the lack of relationship between specific cost drivers and costs.

The collection of meaningful equipment cost information is hindered for the following reasons: 1) the equipment cost is included as part of the development contract and is thus difficult to obtain; 2) equipment may be leased, with no purchase price available; 3) the equipment might be outdated (because of the technological advances over the past 5 years) or might be much cheaper if purchased today; 4) the date on which equipment was purchased is not always available; and 5) the purchasing of equipment is decentralized.

There is no single source to obtain cost information from. Thus, obtaining the cost of all direct equipment will require significant time and resources to exhaust all data sources for each system.

General Support Equipment

Cost information on shared support euqipment is not available in a useable form. The sources for any of this information are decentralized and, of course, it is difficult to break out the costs according to system. Ideally, one would attribute total costs of a piece of equipment based on some measurement of usage. In reality, this is almost impossible to do without being subjective. Even the total costs which are to be divided up among the various systems would be difficult to obtain without significant effort for each piece of information.

Conclusion

In summary it appears to be a very costly and time consuming effort to collect all of the relevant cost information necessary to support avionics software changes. The job is not impossible. It requires a person to check out all data sources and spend a great deal of time with the various supervisors in order to document the evolution of each system. It does not appear to be practical for the Air Force to pursue such a data collection effort because 1) there is some risk that the quantification of cost estimating relationships might not be possible even if sufficient data is collected and 2) the cost of conducting such a study is too great in comparison to the benefits of obtaining an objective cost estimate (which may or may not be better than a subjective one).

APPENDIX
B

AVIONICS SUPPORT COST ESTIMATION QUESTIONNAIRE
(PHASE I)

This questionnaire is to be filled out by knowledgeable people in the field of avionics software support. Because of your background and experience, you have been chosen to help in this study to predict software support costs. Please answer all questions in which you feel you are qualified to provide the necessary information or express an opinion. If you have no experience in the area being questioned, do not answer the question. However, do not be modest—your opinions are important and there are few people in addition to yourselves that are more qualified to answer this questionnaire.

SYSCON has defined avionics software support costs into four categories: direct and indirect labor costs and direct and general support equipment costs. These costs are further broken down according to the work breakdown structure shown on the next page. Please keep in mind the kind of cost referred to by a question as you respond to it.

There are two phases to this questionnaire. This first portion consists of two sections. Section I asks for specific technical and direct labor information about the avionics system to which you are directly assigned. The second section, Section II, concerns various subjects that are less technical in nature but are important for predicting costs other than direct labor necessary to support avionics embedded computer systems.

Sections III and IV will be distributed to you at a later date. They will elicit your expert opinions about how hypothetical changes in certain factors affect direct labor costs.

Please read the instructions at the beginning of each section carefully and answer all questions that you can. Discussion of a particular question with another person or several people is permitted. However, it is important that answers be as reliable as possible. In some cases where information has already been provided to SYSCON, the answers will be filled in. In this circumstance, you are asked merely to confirm your previously supplied data.

AVIONICS SOFTWARE WORK BREAKDOWN STRUCTURE

TOTAL SUPPORT COST

LABOR

INDIRECT
- SUPERVISION
- ADMINISTRATION

DIRECT

EMBEDDED COMPUTER SOFTWARE
- REQUIREMENTS
- REVIEW
- DESIGN
- DEVELOPMENT
- INTEGRATION
- TEST & EVALUATION
- DOCUMENTATION
- REPRODUCTION/INSTALLATION

SUPPORT SOFTWARE

SUPPORT EQUIPMENT

GENERAL
- FACILITY/UTILITIES
- FURNISHINGS
- MATERIAL/SUPPLIES
- COMPUTER/TERMINALS
- MAINTENANCE

DIRECT
- EMBEDDED COMPUTER SYSTEM/INTERFACES
- LAB EQUIPMENT
- SIMULATOR
- SOFTWARE
- TEST AIRCRAFT/TIME
- REPRODUCTION

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APPENDIX B

Name: _____
Org: _____
Phone: _____
Title: _____

SECTION I

Please circle or fill in the correct answer about the avionics system for which you are assigned.

1. Application Type: Navigation OFP   Weapon Delivery
                        EW Jammer   EW Receiver
                        Integrated EW Systems   C-E
                        Fire Control OFP   Other _____

2. PMRT Date: _____

3. Current Block Change Number: _____

4. Year of support _____

5. Documentation Rating at PMRT: None
                                     Incomplete/Outdated
                                     MIL-STD & Up to Date
                                     Other _____

6. Length (in months) of Block Change: _____

7. Development V&V Rating: None
                              Done By Developers
                              Total IV&V on System

8. Test Aircraft Type: Fighter   Bomber   Surveillance   Cargo

9. Reproduction Medium: PROM   ROM   EAROM   Mag Tape   Other _____

10. Number of Fielded Systems: _____

11. Expected System Life: _____

12. Approximate Direct Support Hardware Cost: _____
    Year of Acquisition: _____

13. Approximate Support Software Development Cost: _____
    Year of Acquisition: _____

14. Number of Software Flight Test Hours by year or block change number.
    (Please indicate which)

	1	2	3	4	5	6	7	8	9	10
HRS										

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APPENDIX B

15. History of changes made/changes requested by type. (For example, if in the first block change 10 corrections were requested and 6 were completed you should write 6/10 in the first column.) See definitions on page 101.

	1	2	3	4	5	6	7	8	9	10
Correction										
Deletion										
Addition										
Optimization										
Refinement										
H/W Related										
Other										

Embedded Computer System Information (for the most recent block change)

    16. Type _____

    17. Word Size _____

    18. Percent Fill

        Timing _____

        Memory _____

Embedded Computer Software Information (for the most recent block change)

    19. Language _____

    20. Lines of Code (size in words) _____

Structure

    21. Design Rating   Poor   Fair   Good   Excellent

    22. Implementation Rating   Poor   Fair   Good   Excellent

23.	Complexity Rating	1	2	3	4	5
24.	Rate of Change	1	2	3	4	5
25.	Skill Level Mix	1	2	3	4	5

DEFINITIONS

Complexity Definitions:

(1) Easy to read and follow code, many similar applications.
(2) Time required to gain familiarity with code, many similar applications.
(3) Time required to gain familiarity with code, few similar applications, approaching state-of-the-art.
(4) Extremely difficult to understand code, few similar applications.
(5) Extremely difficult to understand code, unique application, beyond the state-of-the-art.

Rate of Change Definitions:

(1) Stable code, changes required very infrequently, minimal staffing required.
(2) Infrequent changes required on a periodic basis, staffing assigned on a part-time basis.
(3) Changes required on a periodic basis, staffing requirements fairly constant.
(4) Frequent changes, changes require immediate attention, full-time staff required plus additional personnel for pertubations.
(5) Changes required continuously, full-time staff plus additional personnel have difficulty keeping up with user requirements.

Skill Level Mix Definitions:

(1) Predominantly inexperienced, junior personnel unfamiliar with the software system.
(2) Variety of personnel with a limited working knowledge of the software system.
(3) Typical personnel with some experience with the software system, mix of junior and senior personnel.
(4) Predominantly senior personnel with a good working knowledge of the software system.
(5) Highly experienced, senior personnel with an in-depth knowledge of the software system.

Software Change Type Definitions for question 15.

Error correction - due to correcting coding or design deficiencies or errors.

Deletion - eliminating certain code or functional capabilities.

Added capability - additional functions to be performed.

Optimization - to save either core space or execution time.

Refinement - changes to existing capabilities such as changing output from meters to feet.

Hardware related - changes due to processor deficiency or modification.

SUPPORT SOFTWARE

26. For each support software program, list its name, function, whether it is real-time or non-real-time, and also rate whether modifications to each are dependent upon modifications to the embedded computer software.

Program Name	Function	Real-Time/Non-Real-Time	Approximate Yearly Maintenance Cost	Support Dependency Independent				Very Dependent
				1	2	3	4	5
1.				1	2	3	4	5
2.				1	2	3	4	5
3.				1	2	3	4	5
4.				1	2	3	4	5
5.				1	2	3	4	5
6.				1	2	3	4	5
7.				1	2	3	4	5
8.				1	2	3	4	5
9.				1	2	3	4	5
10.				1	2	3	4	5

APPENDIX B

21. For each support software program listed in question 21, fill in its attributes.

Attributes	Program #1	Program #2	Program #3	Program #4	Program #5	Program #6	Program #7	Program #8	Program #9	Program #10
Language										
Lines of Code (Size)										
Design Structure										
Implementation Structure										
Documentation Rating										
Complexity [1]										
Rate of Change [1]										
Skill Level Mix [1]										

[1] See definitions on page 100

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28. You then must examine each change you are familiar with, estimate the number of man-months of effort by grade required to accomplish each phase shown below.

Phase	Civilian						Military				Contractor	TOTAL
Labor Grade	Less than GS-9	GS-9	GS-11	GS-12	GS-13	Greater than GS-13	0-1 or less	0-2	0-3	0-4 or greater		
Requirements Review												
Design												
Development												
Integration												
Test & Evaluation												
Documentation												
Reproduction/ Installation												
Maintaining Support Software												

APPENDIX B

SECTION II

The following questions sometimes require very specific information. If you feel you are not qualified to answer a question, leave the answer blank. However, if you know a source and can obtain the required information, please do so and state the source in the left-hand margin.

Direct Labor

1. For the following grade levels, what is the current average cost per manmonth, including benefits?

Civilian Grade Level	Cost/Manmonth	Military Grade Level	Cost/Manmonth
GS 7	_____	O-1	_____
GS 9	_____	O-2	_____
GS 11	_____	O-3	_____
GS 12	_____	O-4	_____
GS 13	_____	O-5	_____
GS 14	_____	O-6	_____

2. What is the average cost per manmonth for contractors if work is performed

   a) off-site _____?   b) on-site _____?

3. On average how many times more expensive is contractor labor than organic labor if the work is performed a) off-site _____? b) on-site _____?

4. Assuming the developing software contractor has data rights (software is proprietary) estimate the minimum percentage of total manmonths within each phase that would have to be supported by the contractor during a block change? (Go to next page)

Phase	Minimum % of Work Contracted
Requirements Review	_____
Design	_____
Development	_____
Integration	_____
T&E	_____
Documentation	_____
Repro/Installation	_____
TOTAL	_____

5. Assuming 100 manmonths of direct labor were required to maintain the embedded computer software, approximately how many manmonths of direct labor would be required to maintain the support software?

Indirect Labor

6. Assuming 100 manmonths of direct labor were required to complete a block change, approximately how many manmonths of effort would be required for

    a. supervison _____

    b. administration _____

7. What is the average cost per manmonth, including benefits, for supervision and administration, by phase? (NOTE: Cost may be the same for some or all phases.)

Direct Labor Phase	Average Cost/Manmonth	
	Supervision	Administration
Requirements Review	_____	_____
Design	_____	_____
Development	_____	_____
Integration	_____	_____
T&E	_____	_____
Documentation	_____	_____
Repro/Installation	_____	_____
TOTAL	_____	_____

8. Describe the relative increase, if any, in administrative costs caused by increasing the amount of work contracted. Assume that if 0% of the work is performed by contractors, the value is 1.00. For example, if you feel that contracting 50% of the work would increase administrative costs by 20%, you would write 1.20 below the 50 percent column.

	% of work contracted				
	0	25	50	75	100
Relative increase in administrative costs	1.00	__	__	__	__

General Support Equipment

9. Provide the current average cost per square foot for:

   a) facilities (building costs) _____

   b) utilities _____

10. Provide the average number of square feet of space required per person _____

11. Provide the current average cost per person for

   a) desks and furnishings (initial cost) _____

   b) materials and supplies (annual cost) _____

   c) general computer equipment (initial cost) _____

12. Assuming that computer hardware costs $100,000 to purchase, approximately how much would the yearly maintenance cost be? _____

Direct Support Equipment

13. Assuming 100 manhours were expended for test and evaluation during a block change, approximately how many flight test and range time hours would be required?_____

14. What is the cost per flight and test time by aircraft type?

Aircraft Type	Cost/Hour for flight & test time
Cargo	____
Bomber	____
Fighter	____
Surveillance	____

15. What are the reproduction and installation costs for each medium?

Medium	Variable Cost Per Fielded System	Fixed Cost (if any)
PROM	___	___
ROM	___	___
EAROM	___	___
Mag Tape	___	___
Other _____	___	___

APPENDIX
C

AVIONICS SUPPORT COST ESTIMATION QUESTIONNAIRE
(PHASE II)

This questionnaire is to be filled out by knowledgeable people in the field of avionics software support. Because of your background and experience, you have been chosen to help in this study to predict *software support costs*. Please answer all questions in which you feel you are qualified to provide the necessary information or express an opinion. If you have no experience in the area being questioned, do not answer the question. However, do not be modest--your opinions are important and there are few people in addition to yourselves that are more qualified to answer this questionnaire.

SYSCON has defined avionics software support costs into four categories: direct and indirect labor costs and direct and general support equipment costs. These costs are further broken down according to the work breakdown structure shown on the next page. The most important cost component is direct labor expended in supporting the embedded computer system. All of the questions in this second phase of the questionnaire relate to the estimation of direct labor costs. Section III (the first section of Phase II) concerns the impact of certain factors on direct labor costs under several hypothetical conditions. These questions are designed to elicit your best judgment. The final part, Section IV, asks you to define the technical parameters and attributes of an "average" system.

Please read the instructions at the beginning of each section carefully and answer all questions that you can. If you do not understand the question, ask for clarification. You will be given a chance to change your answers at a later date when the results from all respondents are tabulated and made known to you.

AVIONICS SOFTWARE WORK BREAKDOWN STRUCTURE

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SECTION III

The following questions ask for your expert opinion on how a change in one factor impacts on avionics software direct labor costs. When answering these questions assume that all other factors remain unchanged. Also, you may assume (unless otherwise specified) that the following characteristics about a general system apply:

Lines of code: 16K	Program design: unstructured
Language: assembly	Program implementation: unstructured
% memory fill: 75%	Initial documentation: incomplete and outdated
% timing fill: 75%	Year of Support: 3
Work performed: totally organic	Application: Navigation
Development V&V: Performed by developer	Type of Aircraft: Fighter
Complexity rating [1]: 3	Number of fielded systems: 600
Rate of change [1]: 3	Skill Level Mix [1]: 3
Change Efficiency [2]: 50%	

With these characteristics in mind, please answer the following questions about the relative impact on the number of required manhours within each phase of direct labor. For example, if the question asks you to focus on the impact of changing the program size from 16K to 24K, all other factors being equal, you might expect software support direct labor manhours for requirements review to remain the same whereas the labor manhours for the design phase would increase by 15%. That being the case, you would fill in 1.00 in the requirements review block under 24K, and 1.15 in the design block under 24K.

If you feel a situation is not reasonably possible, fill in NA for not applicable.

[1] See page 112 for the definition of each rating.

[2] See page 121 for the definition.

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DEFINITIONS

Complexity Definitions:

(1) Easy to read and follow code, many similar applications.

(2) Time required to gain familiarity with code, many similar applications.

(3) Time required to gain familiarity with code, few similar applications, approaching state-of-the-art.

(4) Extremely difficult to understand code, few similar applications.

(5) Extremely difficult to understand code, unique application, beyond the state-of-the-art.

Rate of Change Definitions:

(1) Stable code, changes required very infrequently, minimal staffing required.

(2) Infrequent changes required on a periodic basis, staffing assigned on a part-time basis.

(3) Changes required on a periodic basis, staffing requirements fairly constant.

(4) Frequent changes, changes require immediate attention, full-time staff required plus additional personnel for pertubations.

(5) Changes required continuously, full-time staff plus additional personnel have difficulty keeping up with user requirements.

Skill Level Mix Definitions:

(1) Predominantly inexperienced, junior personnel unfamiliar with the software system.

(2) Variety of personnel with a limited working knowledge of the software system.

(3) Typical personnel with some experience with the software system, mix of junior and senior personnel.

(4) Predominantly senior personnel with a good working knowledge of the software system.

(5) Highly experienced, senior personnel with an in-depth knowledge of the software system.

1. Relative impact on manhours from a change in the number of lines of code

	Lines of Code				
	4K	8K	16K	24K	32K
Requirements Review			1.00		
Design			1.00		
Development			1.00		
Integration			1.00		
Test & Evaluation			1.00		
Documentation			1.00		
Repro/Installation			1.00		

2. Relative impact on manhours from a change of language

	Language		
	Assembly	Fortran	Structured HOL
Requirements Review	1.00		
Design	1.00		
Development	1.00		
Integration	1.00		
Test & Evaluation	1.00		
Documentation	1.00		
Repro/Installation	1.00		

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APPENDIX C

3.   Relative impact on manhours from changes in the % memory fill

	% Memory Fill					
	50%	75%	90%	95%	98%	100%
Requirements Review		1.00				
Design		1.00				
Development		1.00				
Integration		1.00				
Test & Evaluation		1.00				
Documentation		1.00				
Repro/Installation		1.00				

4.   Relative impact on manhours from a change in % timing fill

	% Timing Fill					
	50%	75%	90%	95%	98%	100%
Requirements Review		1.00				
Design		1.00				
Development		1.00				
Integration		1.00				
Test & Evaluation		1.00				
Documentation		1.00				
Repro/Installation		1.00				

5. Relative impact on manhours from a change in the % of work performed by contractor

	% of work performed by contractor					
	0%	25%	50%	75%	90%	100%
Requirements Review	1.00					
Design	1.00					
Development	1.00					
Integration	1.00					
Test & Evaluation	1.00					
Documentation	1.00					
Repro/Installation	1.00					

6. Relative impact on manhours from a change in development V&V rating

	Development V&V Rating		
	None	Done By Developer	Total IV&V Complete
Requrirements Review		1.00	
Design		1.00	
Development		1.00	
Integration		1.00	
Test & Evaluation		1.00	
Documentation		1.00	
Repro/Installation		1.00	

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APPENDIX C

7. Relative impact on manhours from a change in program design structure

	Program Design			
	Poor	Fair	Good	Excellent
Requirements Review	1.00			
Design	1.00			
Development	1.00			
Integration	1.00			
Test & Evaluation	1.00			
Documentation	1.00			
Repro/Installation	1.00			

8. Relative impact on manhours from a change in program implementation st ture

	Program Implementation			
	Poor	Fair	Good	Excellent
Requirements Review	1.00			
Design	1.00			
Development	1.00			
Integration	1.00			
Test & Evaluation	1.00			
Documentation	1.00			
Repro/Installation	1.00			

APPENDIX C

9. Relative impact on manhours from a change in initial documentation rating

	Initial Documentation		
	None	Incomplete Outdated	MIL-STD Up-to-date
Requirements Review		1.00	
Design		1.00	
Development		1.00	
Integration		1.00	
Test & Evaluation		1.00	
Documentation		1.00	
Repro/Installation		1.00	

10. Relative impact on manhours from a change in the year of support

	Year of Support					
	1	2	3	4	5	6
Requirements Review			1.00			
Design			1.00			
Development			1.00			
Integration			1.00			
Test & Evaluation			1.00			
Documentation			1.00			
Repro/Installation			1.00			

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APPENDIX C

11. Relative impact on manhours from a change in the aircraft type

Type of Aircraft

	Cargo	Bomber	Fighter	Surveillance
Requirements Review			1.00	
Design			1.00	
Development			1.00	
Integration			1.00	
Test & Evaluation			1.00	
Documentation			1.00	
Repro/Installation			1.00	

12. Relative impact on manhours from a change in the number of fielded systems

Number of Fielded Systems

	50	200	600	1000	2000
Requirements Review			1.00		
Design			1.00		
Development			1.00		
Integration			1.00		
Test & Evaluation			1.00		
Documentation			1.00		
Repro/Installation			1.00		

13. Relative impact on manhours from a change in complexity

	1	2	3	4	5
Requirements Review			1.00		
Design			1.00		
Development			1.00		
Integration			1.00		
Test & Evaluation			1.00		
Documentation			1.00		
Repro/Installation			1.00		

Complexity Definitions:

(1) Easy to read and follow code, many similar applications.

(2) Time required to gain familiarity with code, many similar applications.

(3) Time required to gain familiarity with code, few similar applications, approaching state-of-the-art.

(4) Extremely difficult to understand code, few similar applications.

(5) Extremely difficult to understand code, unique application, beyond the state-of-the-art.

APPENDIX C

14. Relative impact on manhours from a change in rate of change

	1	2	3	4	5
Requirements Review			1.00		
Design			1.00		
Development			1.00		
Integration			1.00		
Test & Evaluation			1.00		
Documentation			1.00		
Repro/Installation			1.00		

Rate of Change Definitions:

(1) Stable code, changes required very infrequently, minimal staffing required.

(2) Infrequent changes required on a periodic basis, staffing assigned on a part-time basis.

(3) Changes required on a periodic basis, staffing requirements fairly constant.

(4) Frequent changes, changes require immediate attention, full-time staff required plus additional personnel for perturbations.

(5) Changes required continuously, full-time staff plus additional personnel have difficulty keeping up with user requirements.

APPENDIX C

15. Relative impact on cost from a change in the skill level mix

	1	2	3	4	5
Requirements Review			1.00		
Design			1.00		
Development			1.00		
Integration			1.00		
Test & Evaluation			1.00		
Documentation			1.00		
Repro/Installation			1.00		

Skill Level Mix Definitions:

(1) Predominantly inexperienced, junior personnel unfamiliar with the software system.

(2) Variety of personnel with a limited working knowledge of the software system.

(3) Typical personnel with some experience with the software system, mix of junior and senior personnel.

(4) Predominantly senior personnel with a good working knowledge of the software system.

(5) Highly experienced, senior personnel with an in-depth knowledge of the software system.

16. Relative impact on manhours from a change in efficiency, i.e., the ratio of the number of changes completed to changes requested.

	10%	25%	50%	75%	100%
Efficiency Ratio			1.00		

SECTION IV

Please fill in the specific values for the following characteristics that you feel are representative of an "average" embedded computer system in the field. This should not necessarily reflect your system and may reflect a hypothetical system.

	Navigation	Jammer	Integrated system	Weapon Delivery	Receiver	CE	Fire Control
Lines of Code (1-α)							
Language (Assembly, Fortran, Structured HOL)							
% Memory Fill (0-100)							
% Timing Fill (0-100)							
Development V&V (None, done by developer, IV&V)							
Program Design (Poor, Fair, Good, Excellent)							
Program implementation (Poor, Fair, Good, Excellent)							
Initial documentation (None, incomplete, MIL-STD)							
Year of Support (1-α)							
Type of Aircraft (fighter, bomber, cargo, surveillance)							
Number of fielded systems (1-α)							
Cost of Direct Support Equipment (1-α)							
Complexity $^{1/}$ 1-5							
Rate of Change $^{1/}$ 1-5							
Skill Level Mix $^{1/}$ 1-5							
Change Efficiency 0-100%							

$^{1/}$ See page 112 for the definition of each rating

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APPENDIX
D

APPENDIX D

SUMMARY OF DATA TO SUPPORT THE NORMALIZATION FACTORS

SYSTEM/ SOURCE	SUPER-VISION RATIO	ADMINIS-TRATION RATIO	T&E RATIO	COST PER TEST HOUR	SPARE PER PERSON	BLDG COST PER SQ. FT.	UTILITY COST PER SQ. FT.	FUR-NISHING COST PER PERSON	MAT'L/ SUPPLIES COST PER PERSON	MAINTEN-ANCE RATIO	COMP TERM COST PER PERSON	CONTRACTOR COST PER MANMONTH On Site	Off Site	% WORK FOR SUPPORT SOFTWARE ACTUAL	EST.	% BY CON-TRACTOR IF PRO-PRIETARY	ADMIN. COMPLEXITY FACTOR 0	25	50	75	100
F-111F	.17	.17	.013	2,000¹									8,000	4,500	23.6	25	21	1.00	1.10	1.10	1.20	1.20
F-111A		.20	.016	5,000²	35											100	85	1.00	1.20	1.40	1.60	1.60
F-111D		.06	.013	5,000¹	60								4,167	5,833		30		1.00	1.05	1.10	1.15	1.20
F-16 FCC		.06	.073	1,000¹									4,167	5,833	50	1	85	1.00	1.05	1.10	1.15	1.20
F-16 SMS		.07	.020													30		1.00	1.25	1.50	1.75	2.00
ALQ-155		.06	.070	5,000²									10,000	8,000	25	100	50	1.00	1.10	1.20	1.30	1.40
ALR-62		.07	.08	2,000²					400		.10	20,000	10,000			5						
ALR-46		.07	.06					510	85	.08	20,500				200		1.00	1.13	1.25	1.38	1.50
ALQ-131		.08	.06		100	75.00	1.20	400		.05		8,300	10,000	0	10	50					
ALR-69		.10	.06	2,000¹	110		.60	510	85	.08		5,000		0	8		1.00	1.00	1.10	1.20	1.30
APR-38		.08	.10	2,000¹	324	46.00	4.60	660	415	.05			9,100	37	45	60	1.00	1.05	1.10	1.15	1.10
E-3A		.12	.036	6,000³	46			660	356	.10	20,033	10,000		20	30	15					
A-7		.04	.020	2,000¹	100	101.00		272+	400	.10	10,000				5	50					
F-4 (ID)		.15	.040		130	130.00		660	700						10						
F-4 (ALR)		.10	.060		125	113.00	4.60	400		.11											
00 ALC																					
SM ALC																					
OC ALC																					
SELECTED AVERAGE	.13	.13	4	5	0	130.00	1.20	660	700	.10	20,000	7,000	7,000	7		50	1.00	1.125	1.25	1.375	1.50

¹FIGHTER
²BOMBER
³SURVEILLANCE

⁴OFF: .03
EW: .06
CE: .036

⁵FIGHTER: $2,000
BOMBER: $5,000

⁶FIGHTER:
BOMBER:

⁷MAINTENANCE OF SUPPORT SOFTWARE: 30
NO MAINTENANCE OF SUPPORT SOFTWARE: 0

⁸TECHNICAL: 275
SUPERVISOR/ADMINISTRATOR: 130

APPENDIX
E

APPENDIX E

PERSONNEL COST INFORMATION

GS Grade	Annual Base Salary 1/	Military Grade	Monthly Base Salary 2/
GS 1	$8,398	0-1	$1,329
GS 2	9,764	0-2	1,651
GS 3	10,907	0-3	2,112
GS 4	12,683	0-4	2,446
GS 5	14,893	0-5	3,034
GS 6	16,926	0-6	3,549
GS 7	18,336	0-7	4,176
GS 8	21,586	0-8	4,176
GS 9	22,719	0-9	4,176
GS 10	25,385	0-10	4,176
GS 11	27,076		
GS 12	32,729		
GS 13	40,311		
GS 14	47,284		
GS 15	50,112		
GS 16	50,112		

1/ Provided by Mr. Jerry Carter, HQTRS AFLC/NPKP WPAFB, 10/21/81. Figures include 4.8% cost-of-living raise effective 10/1/81.

2/ Provided by Mr. Jerry Carter 10/27/81.

APPENDIX
F

APPENDIX F

RESPONDENTS TO PHASE II QUESTIONNAIRE

Name	Location	Classification
Wayne Lord	SM-ALC	MMECA
John Hancock	SM-ALC	Autonetics
Ben Alsep	SM-ALC	MMECA
Bob Alley	SM-ALC	MMECA
Thomas Broers	SM-ALC	MMECA
Jim Sheppard	SM-ALC	Rockwell International
?	SM-ALC	General Dynamics
Greg Straton	Point Mugu	USN
Richard Desposato	Point Mugu	USN
David Erickson	OO-ALC	MMECA
Russ Suzuki	OO-ALC	MMECA
Eldon Jensen	OO-ALC	MMECA
Valon Stock	OO-ALC	MMECA
Leon Oldham	OO-ALC	MMECA
Jim Healey	OO-ALC	MMECA
Mike Welch	OO-ALC	MMECA
Dea Johnson	OO-ALC	MMECA
Lt. Robert Sikes	OC-ALC	AWACS
Willis Janssen	OC-ALC	AWACS
Lt. James Hart	OC-ALC	AWACS
James Walker	OC-ALC	MMECM
Joseph King	OC-ALC	MMECO
Tom King	OC-ALC	MMECO
George Wann	OC-ALC	MMECM
Coy Sullivan	OC-ALC	MMECT
Tom Reyenga	OC-ALC	MMECT
Michael Ryan	OC-ALC	MMECO
Leonard Wilson	OC-ALC	MMECT
Capt. Russell Hammerad	OC-ALC	AWACS
Novie White	WR-ALC	MMECDA
Victor Vajo	WR-ALC	MMECDA
Harry Jennings	WR-ALC	MMRRVC
John Echols	WR-ALC	MMECDF
Suzanne Mason	WR-ALC	MMRRCC
Jim McKeen	WR-ALC	MMECDA
John Louth	WR-ALC	MMRRVA
Ron Parker	WR-ALC	MMECV
Jim Hundley	WR-ALC	MMRRIA
Ken Obst	WR-ALC	MMECDF

APPENDIX
G

APPENDIX G
FOLLOW-UP LETTER WITH PHASE II QUESTIONAIRE

SYSCON
CORPORATION

1054 31ST STREET, N.W.
WASHINGTON, D.C. 20007
PHONE: (202) 342-4000
TWX: (710) 822-0103

You may recall that earlier this year, Rich Bentley and I visited your Air Logistics Center in order to collect information concerning the costs of maintaining embedded computer software. SYSCON Corporation is under contract from the Avionics Lab at Wright-Patterson to develop a computer model to estimate these costs during the conceptual stage of avionics system design.

You were chosen to take part in Phase II of our two-phase questionnaire. Because of the subjective nature of the information requested, we feel the reliability of the data you provided would be enhanced if you had one final opportunity to review your answers. This method for data collection, known as the Delphi Technique, requests you to compare your answers to the averages computed from the answers provided by all of the respondents. You thus have one last opportunity to change any or all of your answers.
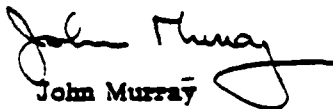
The purpose of this final review is to allow you to see how your peers interpreted the same questions. We have enclosed a computer printout of each question and your previous answers. Below each of your answers is the average as computed from all 39 respondents. In this way we hope we have made it simple for you to compare your previous answers to the averages. Please also keep in mind that some questions were misinterpreted. You should note this when comparing your answers to the averages.

In computing averages we have omitted answers left blank. In addition, we set a limit of 10 to reduce the impact of any one answer on the computed averages. Thus, if a respondent felt that costs would increase by a factor of 10 or more, an answer of 10 was substituted. We would greatly appreciate your help one last time so that we can finalize our mathematical algorithms. If you feel any changes are in order or wish to fill in answers you previously left blank, simply cross out your old answer and insert the new one in its place. Keep in mind that you do not have to change your answers. It will be easier for us if you work with a red pencil or pen. Also, if your answer and the group average are both shown to be 1.00, no changes are necessary. You may recall that these were present only to establish a point of reference and are not subject to change.

This review should take you no more than half an hour. When you are finished, please return the questionnaire in the self-addressed, stamped envelop enclosed for this purpose by 12 December 1981. If there are any questions, please feel free to call me at 800-424-8503.

Thank you very much for your help and support.

Sincerely,

John Murray

AVIONICS SUPPORT COST ESTIMATION QUESTIONNAIRE
(PHASE II)

This questionnaire is to be filled out by knowledgeable people in the field of avionics software support. Because of your background and experience, you have been chosen to help in this study to predict software support costs. Please answer all questions in which you feel you are qualified to provide the necessary information or express an opinion. If you have no experience in the area being questioned, do not answer the question. However, do not be modest—your opinions are important and there are few people in addition to yourselves that are more qualified to answer this questionnaire.

SYSCON has defined avionics software support costs into four categories: direct and indirect labor costs and direct and general support equipment costs. These costs are further broken down according to the work breakdown structure shown on the next page. The most important cost component is direct labor expended in supporting the embedded computer system. All of the questions in this second phase of the questionnaire relate to the estimation of direct labor costs. Section III (the first section of Phase II) concerns the impact of certain factors on direct labor costs under several hypothetical conditions. These questions are designed to elicit your best judgment. The final part, Section IV, asks you to define the technical parameters and attributes of an "average" system.

Please read the instructions at the beginning of each section carefully and answer all questions that you can. If you do not understand the question, ask for clarification. You will be given a chance to change your answers at a later date when the results from all respondents are tabulated and made known to you.

AVIONICS SOFTWARE WORK BREAKDOWN STRUCTURE

Name: _____
Org: _____
Phone: _____
Title: _____

SECTION III

The following questions ask for your expert opinion on how a change in one factor impacts on avionics software direct labor costs. When answering these questions assume that all other factors remain unchanged. Also, you may assume (unless otherwise specified) that the following characteristics about a general system apply:

Lines of code: 16K	Program design: unstructured
Language: assembly	Program implementation: unstructured
% memory fill: 75%	Initial documentation: incomplete and outdated
% timing fill: 75%	Year of Support: 3
Work performed: totally organic	Application: Navigation
Development V&V: Performed by developer	Type of Aircraft: Fighter
Complexity rating [1]: 3	Number of fielded systems: 600
Rate of change [1]: 3	Skill Level Mix [1]: 3
Change Efficiency [2]: 50%	

With these characteristics in mind, please answer the following questions about the relative impact on the number of required manhours within each phase of direct labor. For example, if the question asks you to focus on the impact of changing the program size from 16K to 24K, all other factors being equal, you might expect software support direct labor manhours for requirements review to remain the same whereas the labor manhours for the design phase would increase by 15%. That being the case, you would fill in 1.00 in the requirements review block under 24K, and 1.15 in the design block under 24K.

If you feel a situation is not reasonably possible, fill in NA for not applicable.

[1] See page 134 for the definition of each rating.

[2] See page 142 for the definition.

DEFINITIONS

Complexity Definitions:

   (1) Easy to read and follow code, many similar applications.

   (2) Time required to gain familiarity with code, many similar applications.

   (3) Time required to gain familiarity with code, few similar applications, approaching state-of-the-art.

   (4) Extremely difficult to understand code, few similar applications.

   (5) Extremely difficult to understand code, unique application, beyond the state-of-the-art.

Rate of Change Definitions:

   (1) Stable code, changes required very infrequently, minimal staffing required.

   (2) Infrequent changes required on a periodic basis, staffing assigned on a part-time basis.

   (3) Changes required on a periodic basis, staffing requirements fairly constant.

   (4) Frequent changes, changes require immediate attention, full-time staff required plus additional personnel for pertubations.

   (5) Changes required continuously, full-time staff plus additional personnel have difficulty keeping up with user requirements.

Skill Level Mix Definitions:

   (1) Predominantly inexperienced, junior personnel unfamiliar with the software system.

   (2) Variety of personnel with a limited working knowledge of the software system.

   (3) Typical personnel with some experience with the software system, mix of junior and senior personnel.

   (4) Predominantly senior personnel with a good working knowledge of the software system.

   (5) Highly experienced, senior personnel with an in-depth knowledge of the software system.

134

1. RELATIVE IMPACT ON MANHOURS FROM A CHANGE IN THE NUMBER OF LINES OF CODE. ASSUME THAT THE REQUIREMENTS OF THE VARIOUS PROGRAM SIZES REFLECT THEIR RELATIVE COMPLEXITY. THUS, IT IS OBVIOUS THAT A 32K PROGRAM IS MUCH MORE COMPLEX THAN A 4K PROGRAM.

LINES OF CODE

	4K	8K	16K	24K	32K
REQUIREMENTS REVIEW	.60	.80	1.00	1.20	1.40
AVERAGE	.64	.80	1.00	1.20	1.45
DESIGN	.50	.75	1.00	1.25 *[1.30]* *1.80*	1.50 *1.60*
AVERAGE	.61	.78	1.00	1.30	1.73
DEVELOPMENT	.50	.75	1.00	1.25	1.50
AVERAGE	.62	.78	1.00	1.32	1.63
INTEGRATION	.40 *60*	.80 *80*	1.00	1.10 *130*	1.20 *1.60*
AVERAGE	.63	.80	1.00	1.35	1.69
TEST & EVALUATION	.50	.75	1.00	1.25 *130*	1.50 *1.60*
AVERAGE	.61	.75	1.00	1.30	1.60
DOCUMENTATION	.25 *.60*	.50 *.75*	1.00	1.50 *1.25*	2.00 *1.50*
AVERAGE	.62	.70	1.00	1.25	1.50
REPRO/INSTALLATION	.50 *.80*	.75 *.90*	1.00	1.50 *1.10*	2.00 *1.20*
AVERAGE	.85	.91	1.00	1.09	1.18

2. RELATIVE IMPACT ON MANHOURS FROM A CHANGE OF LANGUAGE.

LANGUAGE

	ASSEMBLY	FORTRAN	STRUCTURED HOL
REQUIREMENTS REVIEW	1.00	.75 *1.00*	.75 *1.00*
AVERAGE	1.00	.90	1.00
DESIGN	1.00	.75 *.90*	.50 *.90*
AVERAGE	1.00	.87	.93
DEVELOPMENT	1.00	.75	.50
AVERAGE	1.00	.72	.76
INTEGRATION	1.00	.90	.80
AVERAGE	1.00	.89	.87
TEST & EVALUATION	1.00	.80	.75
AVERAGE	1.00	.80	.87
DOCUMENTATION	1.00	.90	.80
AVERAGE	1.00	.85	.80
REPRO/INSTALLATION	1.00	1.00	1.00
AVERAGE	1.00	.95	.95

3. RELATIVE IMPACT ON MANHOURS FROM A CHANGE IN THE % MEMORY FILL.

	% MEMORY FILL					
	50%	75%	90%	95%	98%	100%
REQUIREMENTS REVIEW	1.00	1.00	1.00	1.00	1.00	1.00
AVERAGE	.90	1.00	1.10	1.35	1.60	2.22
DESIGN	1.00	1.00	1.20	1.40	1.60	2.00
AVERAGE	.86	1.00	1.40	1.95	2.50	3.42
DEVELOPMENT	1.00	1.00	1.40	1.60	1.70	2.00
AVERAGE	.87	1.00	1.46	1.97	2.45	3.14
INTEGRATION	1.00	1.00	1.00	1.10 *(1.50)*	1.30 *(1.80)*	1.40 *(2.00)*
AVERAGE	.91	1.00	1.25	1.54	1.89	2.68
TEST & EVALUATION	1.00	1.00	1.00 *(1.20)*	1.40	1.50	1.50 *(1.70)*
AVERAGE	.93	1.00	1.21	1.40	1.55	1.82
DOCUMENTATION	1.00	1.00	1.00	1.10	1.15	1.20
AVERAGE	.94	1.00	1.05	1.09	1.15	1.20
REPRO/INSTALLATION	1.00	1.00	1.00	1.00	1.00	1.00
AVERAGE	.96	1.00	1.01	1.02	1.02	1.04

4. RELATIVE IMPACT ON MANHOURS FROM A CHANGE IN THE % TIMING FILL.

	% TIMING FILL					
	50%	75%	90%	95%	98%	100%
REQUIREMENTS REVIEW	.95	1.00	1.00	1.00	1.00	1.00
AVERAGE	.95	1.00	1.06	1.26	1.53	1.79
DESIGN	.90	1.00	1.20	1.50	2.00	2.00 *(3.00)*
AVERAGE	.86	1.00	1.31	1.77	2.35	3.01
DEVELOPMENT	.85	1.00	1.20	1.80	2.00	2.50 *(3.00)*
AVERAGE	.87	1.00	1.36	1.85	2.22	3.05
INTEGRATION	.95	1.00	1.20	1.50	1.80	2.00
AVERAGE	.94	1.00	1.22	1.51	1.86	2.50
TEST & EVALUATION	.95	1.00	1.20	1.5	1.70	2.00
AVERAGE	.94	1.00	1.25	1.40	1.65	1.90
DOCUMENTATION	.98	1.00	1.00	1.00	1.00	1.00
AVERAGE	.96	1.00	1.02	1.07	1.09	1.10
REPRO/INSTALLATION	.97	1.00	1.00	1.00	1.00	1.00
AVERAGE	.97	1.00	1.00	1.03	1.01	1.07

5. RELATIVE IMPACT ON TOTAL MANHOURS (BOTH ORGANIC AND CONTRACTOR) FROM A CHANGE IN THE % OF WORK PERFORMED BY CONTRACTORS.

	% OF WORK PERFORMED BY CONTRACTORS					
	0%	25%	50%	75%	90%	100%
REQUIREMENTS REVIEW	1.00	1.00	1.00	1.00	1.00	1.00
AVERAGE	1.00	1.19	1.29	1.31	1.33	1.37
DESIGN	1.00	1.20	1.20	1.25	1.30	1.35
AVERAGE	1.00	1.21	1.33	1.34	1.31	1.35
DEVELOPMENT	1.00	1.10	1.10	1.20	1.30	1.40
AVERAGE	1.00	1.19	1.26	1.29	1.26	1.30
INTEGRATION	1.00	1.10	1.10	1.20	1.30	1.35
AVERAGE	1.00	1.20	1.26	1.29	1.27	1.24
TEST & EVALUATION	1.00	1.10	1.10	1.20	1.30	1.35
AVERAGE	1.00	1.17	1.27	1.26	1.29	1.34
DOCUMENTATION	1.00	1.10	1.10	1.20	1.30	1.40
AVERAGE	1.00	1.15	1.21	1.24	1.27	1.31
REPRO/INSTALLATION	1.00	1.00	1.00	1.00	1.00	1.00
AVERAGE	1.00	1.03	1.03	1.05	1.06	1.04

6. RELATIVE IMPACT ON MANHOURS FROM A CHANGE IN DEVELOPMENT V&V RATING.

	DEVELOPMENT V&V RATING		
	NONE	DONE BY DEVELOPER	TOTAL IV&V COMPLETE
REQUIREMENTS REVIEW	1.00	1.00	1.00
AVERAGE	1.37	1.00	.97
DESIGN	1.10	1.00	.80
AVERAGE	1.51	1.00	.87
DEVELOPMENT	1.10	1.00	.75
AVERAGE	1.50	1.00	.80
INTEGRATION	1.00	1.00	.75
AVERAGE	1.54	1.00	.84
TEST & EVALUATION	1.25	1.00	.75
AVERAGE	1.84	1.00	.84
DOCUMENTATION	1.00	1.00	1.00
AVERAGE	1.50	1.00	.91
REPRO/INSTALLATION	1.00	1.00	1.00
AVERAGE	1.13	1.00	1.00

7. RELATIVE IMPACT ON MANHOURS FROM A CHANGE IN PROGRAM DESIGN STRUCTURE.

PROGRAM DESIGN

	POOR	FAIR	GOOD	EXCELLENT
REQUIREMENTS REVIEW	1.00	.80	.70	.50
AVERAGE	1.00	.93	.92	.84
DESIGN	1.00	.80	.70	.50
AVERAGE	1.00	.91	.85	.82
DEVELOPMENT	1.00	.80	.70	.50
AVERAGE	1.00	.91	.86	.84
INTEGRATION	1.00	.90	.80	.70
AVERAGE	1.00	.89	.80	.71
TEST & EVALUATION	1.00	.80	.70	.50
AVERAGE	1.00	.91	.81	.70
DOCUMENTATION	1.00	.90	.80	.70
AVERAGE	1.00	.89	.80	.70
REPRO/INSTALLATION	1.00	1.00	1.00	1.00
AVERAGE	1.00	.90	.90	.93

8. RELATIVE IMPACT ON MANHOURS FROM A CHANGE IN PROGRAM IMPLEMENTATION STRUCTURE.

PROGRAM IMPLEMENTATION

	POOR	FAIR	GOOD	EXCELLENT
REQUIREMENTS REVIEW	1.00	.90	.70	.60
AVERAGE	1.00	.90	.91	.80
DESIGN	1.00	.90	.80	.70
AVERAGE	1.00	.92	.86	.81
DEVELOPMENT	1.00	.90	.80	.70
AVERAGE	1.00	.90	.82	.75
INTEGRATION	1.00	.90	.70	.60
AVERAGE	1.00	.80	.70	.64
TEST & EVALUATION	1.00	.80	.70	.70
AVERAGE	1.00	.90	.82	.72
DOCUMENTATION	1.00	.90	.90	.80
AVERAGE	1.00	.92	.84	.75
REPRO/INSTALLATION	1.00	1.00	1.00	1.00
AVERAGE	1.00	.97	.94	.90

APPENDIX G

9. RELATIVE IMPACT UN MANHOURS FRUM A CHANGE IN INITIAL DOCUMENTATION RATING.

INITIAL DUCUMENTATION
****

	NONE	INCOMPLETE OUTUATED	MIL-STD UP-TU-UATE
	********	********	********
REQUIREMENTS REVIEW	3.00	1.00	.50
AVERAGE	2.81	1.00	.69
DESIGN	4.00	1.00	.50
AVERAGE	4.03	1.00	.56
DEVELOPMENT	3.50	1.00	.50
AVERAGE	3.64	1.00	.61
INTEGRATIUN	4.00	1.00	.75
AVERAGE	3.87	1.00	.6c
TEST & EVALUATIUN	3.00	1.00	.80
AVERAGE	3.04	1.00	.66
DUCUMENTATIUN	4.00	1.00	.50
AVERAGE	4.06	1.00	.59
REPRO/INSTALLATION	2.00	1.00	1.00
AVERAGE	2.02	1.00	.84

10. RELATIVE IMPACT UN MANHOURS FRUM A CHANGE IN THE YEAR OF SUPPORT.

YEAR OF SUPPORT
****

	1	2	3	4	5	6
	********	********	********	********	********	********
REQUIREMENTS REVIEW	2.00	1.20	1.00	.80	.75	.75
AVERAGE	1.77	1.25	1.00	.96	.96	.97
DESIGN	2.00	1.25	1.00	.80	.75	.75
AVERAGE	1.77	1.32	1.00	.95	.95	.94
DEVELOPMENT	2.00	1.25	1.00	.80	.75	.75
AVERAGE	1.79	1.35	1.00	.95	.94	.95
INTEGRATIUN	1.20	1.10	1.00	.90	.80	.80
AVERAGE	1.94	1.37	1.00	.95	.96	.97
TEST & EVALUATIUN	1.50	1.20	1.00	.80	.75	.75
AVERAGE	1.73	1.35	1.00	.96	.97	1.00
DOCUMENTATIUN	1.5	1.25	1.00	1.00	1.00	1.00
AVERAGE	1.53	1.23	1.00	.97	.96	1.00
REPRO/INSTALLATION	1.00	1.00	1.00	1.00	1.00	1.00
AVERAGE	1.30	1.12	1.00	.96	1.00	1.03

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11. RELATIVE IMPACT UN MANHOURS FRUM A CHANGE IN THE AIRCRAFT TYPE.

TYPE OF AIRCRAFT
****

	LARGO	BOMBER	FIGHTER	SURVEIL-LANCE
	********	********	********	********
REQUIREMENTS REVIEW AVERAGE	.83	1.02	1.00	.98
DESIGN AVERAGE	.80	1.02	1.00	1.01
DEVELUPMENT AVERAGE	.80	1.01	1.00	1.02
INTEGRATION AVERAGE	.79	1.03	1.00	1.02
TEST & EVALUATION AVERAGE	.80	.99	1.00	1.01
DUCUMENTATION AVERAGE	.89	1.02	1.00	.99
REPRO/INSTALLATION AVERAGE	.00	1.00	1.00	.99

12. RELATIVE IMPACT UN MANHOURS FRUM A CHANGE IN THE NUMBER OF FIELDED SYSTEMS.

NUMBER OF FIELDED SYSTEMS
****

	50	200	600	1000	2000
	********	********	********	********	********
REQUIREMENTS REVIEW	1.00	1.00	1.00	1.00	1.00
AVERAGE	.96	.94	1.00	1.02	1.04
DESIGN	1.00	1.00	1.00	1.00	1.00
AVERAGE	.99	1.00	1.00	1.01	1.02
DEVELUPMENT	1.00	1.00	1.00	1.00	1.00
AVERAGE	.99	1.00	1.00	1.01	1.02
INTEGRATION	1.00	1.00	1.00	1.00	1.00
AVERAGE	.97	.98	1.00	1.02	1.06
TEST & EVALUATION	1.00	1.00	1.00	1.00	1.00
AVERAGE	.98	.96	1.00	1.01	1.07
DUCUMENTATION	1.00	1.00	1.00	1.00	1.00
AVERAGE	.99	1.00	1.00	1.00	1.01
REPRO/INSTALLATION	.10	.30	1.00	1.50	2.00
AVERAGE	.62	.75	1.00	1.31	2.02

13.   RELATIVE IMPACT ON MANHOURS FROM A CHANGE IN COMPLEXITY.

COMPLEXITY RATING

	1	2	3	4	5
REQUIREMENTS REVIEW	.70	.90	1.00	*1.5* ~~1.20~~	*2.00* ~~1.50~~
AVERAGE	.73	.85	1.00	1.57	2.24
DESIGN	.50	.80	1.00	*2.00* ~~1.50~~	*3.00* ~~2.00~~
AVERAGE	.52	.75	1.00	2.10	3.51
DEVELOPMENT	.60	.80	1.00	*2.00* ~~1.50~~	*3.00* ~~2.00~~
AVERAGE	.51	.75	1.00	2.12	3.52
INTEGRATION	*.65* ~~.50~~	*.80* ~~.50~~	1.00	*2.00* ~~1.50~~	*3.00* ~~1.50~~
AVERAGE	.60	.80	1.00	2.05	3.33
TEST & EVALUATION	.70	.90	1.00	*1.70* ~~1.20~~	*2.75* ~~1.50~~
AVERAGE	.65	.84	1.00	1.70	2.81
DOCUMENTATION	*.75* ~~1.00~~	*.90* ~~1.00~~	1.00	*1.50* ~~1.00~~	*2.50* ~~1.00~~
AVERAGE	.71	.87	1.00	1.63	2.57
REPRO/INSTALLATION	1.00	1.00	1.00	1.00	1.00
AVERAGE	.97	.99	1.00	1.05	1.11

14.   RELATIVE IMPACT ON MANHOURS FROM A CHANGE IN RATE OF CHANGE.

RATE OF CHANGE RATING

	1	2	3	4	5
REQUIREMENTS REVIEW	.30	.50	1.00	1.10	1.20
AVERAGE	.74	.8c	1.00	1.30	1.90
DESIGN	.60	.75	1.00	*1.50* ~~1.30~~	*2.00* ~~1.50~~
AVERAGE	.76	.84	1.00	1.54	2.27
DEVELOPMENT	.60	.75	1.00	*1.50* ~~1.25~~	*2.00* ~~1.50~~
AVERAGE	.72	.84	1.00	1.50	2.34
INTEGRATION	.80	.90	1.00	*1.50* ~~1.25~~	*2.00* ~~1.50~~
AVERAGE	.60	.81	1.00	1.50	2.37
TEST & EVALUATION	.60	.75	1.00	*1.50* ~~1.25~~	*2.00* ~~1.50~~
AVERAGE	.72	.82	1.00	1.50	2.24
DOCUMENTATION	.50	.75	1.00	*1.75* ~~1.25~~	*2.5* ~~1.50~~
AVERAGE	.60	.76	1.00	1.81	2.54
REPRO/INSTALLATION	*.75* ~~.50~~	*.85* ~~.50~~	1.00	*1.50* ~~1.10~~	*2.00* ~~1.20~~
AVERAGE	.58	.79	1.00	1.42	1.97

15. RELATIVE IMPACT ON COST (NOT MANHOURS) FROM A CHANGE IN THE SKILL LEVEL MIX

SKILL LEVEL MIX RATING

	1	2	3	4	5
REQUIREMENTS REVIEW	3.00	1.50	1.00	.80	.60
AVERAGE	2.69	1.73	1.00	.81	.69
DESIGN	3.00	2.00	1.00	.75	.50
AVERAGE	3.16	1.94	1.00	.76	.58
DEVELOPMENT	3.00	2.00	1.00	.75	.50
AVERAGE	2.97	1.88	1.00	.77	.59
INTEGRATION	3.00	2.00	1.00	.75	.50
AVERAGE	3.19	2.07	1.00	.77	.60
TEST & EVALUATION	3.00	1.50	1.00	.80	.70
AVERAGE	2.60	1.71	1.00	.82	.70
DOCUMENTATION	2.00	1.50	1.00	.85	.75
AVERAGE	2.15	1.47	1.00	.88	.76
REPRO/INSTALLATION	1.10	1.00	1.00	1.00	1.00
AVERAGE	1.51	1.22	1.00	.96	.93

16. RELATIVE IMPACT ON MANHOURS FROM A CHANGE IN EFFICIENCY, THAT IS, THE
RATIO OF THE NUMBER OF CHANGES COMPLETED TO CHANGES REQUESTED. FOR
EXAMPLE, IF 100 CHANGES WERE REQUESTED, WHAT IS THE RELATIVE IMPACT ON
MANHOURS IF 10 (OR 10%) WERE COMPLETED, 25 (OR 25%)? ETC.

EFFICIENCY RATING

	10%	25%	50%	75%	100%
ALL PHASES	.40	.60	1.00	1.20	1.50
AVERAGE	.35	.59	1.00	1.59	2.43

APPENDIX
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APPENDIX H

F - 111F

(OFP) Navigation Weapon Delivery

Historical System

APPENDIX H

F - 111F

(OFP) NAVIGATION WEAPON DELIVERY

BREAK DOWN OF ANNUAL COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1991

TOTAL ANNUAL COST   13277969.

```
TOTAL LABOR                                                  578679.
    DIRECT LABOR                              503468.
        REQUIREMENTS REVIEW        33963.
        DESIGN                     56388.
        DEVELOPMENT                56375.
        INTEGRATION                85937.
        TEST AND EVALUATION       100767.
        DOCUMENTATION              54849.
        REPRODUCTION/INSTALL       12274.
        SUPPORT SOFTWARE          102916.
    INDIRECT LABOR                             75211.
        SUPERVISION                47711.
        ADMINISTRATION             27500.

TOTAL SUPPORT EQUIPMENT                                     12699290.
    DIRECT                                    7567940.
        HARDWARE                 5078100.
        SUPPORT SOFTWARE         2343800.
        TEST AIRCRAFT TIME        144000.
        REPRODUCTION                2040.
    GENERAL                                   5131350.
        FACILITY                   29716.
        UTILITIES                   2622.
        FURNISHINGS                  612.
        MATERIALS & SUPPLIES        6300.
        COMPUTERS/TERMINALS        14000.
        HARDWARE MAINTENANCE     5078100.
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APPENDIX H

F - 111F

(UFP) NAVIGATION WEAPON DELIVERY

DERIVATION OF DIRECT LABOR COSTS BY GRADE
HISTORICAL SYSTEM
YEAR 1981

PHASE	GRADE	NUMBER OF MANMONTHS	COST PER MANMONTH	COST PER GRADE	DIRECT LABOR COST
1. REQUIREMENTS REVEIW					33963.
	GS-11	1.00	2969.	2969.	
	GS-13	0.07	4390.	293.	
	O-3	1.00	3168.	3168.	
	CNTR	3.93	7000.	27533.	
2. DESIGN					56388.
	GS-11	1.13	2969.	3365.	
	O-3	0.53	3168.	1690.	
	CNTR	7.33	7000.	51333.	
3. DEVELOPMENT					56375.
	GS-11	1.20	2969.	3563.	
	O-3	0.47	3168.	1478.	
	CNTR	7.33	7000.	51333.	
4. INTEGRATION					85937.
	GS-11	1.00	2969.	2969.	
	O-3	1.00	3168.	3168.	
	CNTR	11.40	7000.	79800.	
5. TEST AND EVALUATION					100767.
	GS-11	2.00	2969.	5938.	
	GS-13	0.07	4390.	293.	
	O-3	2.00	3168.	6336.	
	CNTR	12.60	7000.	88200.	
6. DOCUMENTATION					54849.
	GS-11	1.33	2969.	3959.	
	O-3	1.33	3168.	4224.	
	CNTR	6.67	7000.	46667.	
7. REPRO/INSTALLATION					12274.
	GS-11	2.00	2969.	5938.	
	O-3	2.00	3168.	6336.	
8. SUPPORT SOFTWARE					102916.
	GS-11	1.33	2969.	3959.	
	O-3	1.33	3168.	4224.	
	CNTR	13.53	7000.	94733.	
TOTAL		83.60	6045.	503468.	503468.

NOTE: ACTUAL BLOCK CHANGE LENGTH IS 18 MONTHS

APPENDIX B

F - 111F

(NFP) NAVIGATION WEAPON DELIVERY

DERIVATION OF ANNUAL INDIRECT LABOR COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1981

SUPERVISION

DIRECT ANNUALIZED ON-SITE MANMONTHS X SUPERVISN RATIO = SUPERVISN MANMONTHS
          83.60   X   0.13   =   10.87

SUPERVISION MANMONTHS X COST/MANMONTH = SUPERVISION COST
     10.87   X   4390.   =   47711.

ADMINISTRATIVE

DIRECT ANNUALIZED ON-SITE MANMONTHS X ADMNSTIVE RATIO = ADMNSTIVE MANMONTHS
          83.60   X   0.13   =   10.87

ADMNSTIVE MANMONTHS X COST/MANMONTH X ADM COMP-FACT = ADMNSTIVE COST
     10.87   X   1847.   X   1.370   =   27500.

TOTAL INDIRECT LABOR

SUPERVISION + ADMINISTRATIVE = INDIRECT LABOR COSTS
   47711.   +   27500.   =   75211.

APPENDIX H

F - 111F

(OFP) NAVIGATION WEAPON DELIVERY

DERIVATION OF ANNUAL DIRECT SUPPORT EQUIPMENT COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1981

EQUIPMENT

	HARDWARE	SUPPORT SOFTWARE	TOTAL
INITIAL COST (1981S)	50781000.	23438000.	74219000.
COST (1981S)	50781000.	23438000.	74219000.
EXPECTED SYSTEM LIFE	10	10	10
ANNUAL EQUIPMENT COST	5078100.	2343800.	7421900.

TEST AIRCRAFT/TIME

ANNUAL T&E MANMONTHS X 144 = ANNUAL T&E MANHOURS
     16.09   X 144 =   2400.00

ANNUAL T&E MANHOURS X T&E RATIO = TEST AIRCRAFT HOURS
   2400.00   X 0.030   =   72.00

TEST AIRCRAFT HOURS X COST/HOUR = ANNUAL AIRCRAFT/TIME COST
   72.00   X   2000. =   144000.

REPRODUCTION

NUMBER OF FIELDED SYSTEMS X MED REP-FACT X COST/REPRO = REPRODUCTION COST
     90   X   2.000   X 17.00   =   3060.

REPRODUCTION COST X 12 / BLOCK CHANGE LENGTH = ANNUAL REPRODUCTION COST
   3060.   X 12 /   18   =   2040.

DIRECT SUPPORT EQUIPMENT COSTS

DIRECT HARDWARE COST	5078100.
DIRECT SOFTWARE COST	2343800.
AIRCRAFT/TIME COST	144000.
+ REPRODUCTION COST	2040.
DIRECT SUPPORT EQUIPMENT COST	7567940.

APPENDIX H

F - 111F

(OFP) NAVIGATION WEAPON DELIVERY

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1981

PEOPLE REQUIRED

REQUIRED ANNUAL ON-SITE MANMONTHS / 12 = NO. OF DIRECT SUPPORT PEOPLE
        83.60   / 12 =   7

ANNUAL SUPERVISION MANMONTHS / 12 = NO. OF SUPERVISORS
      10.97   / 12 =   1

ANNUAL ADMINISTRATIVE MANMONTHS / 12 = NO. OF ADMINISTRTRS
      10.87   / 12 =   1

NO. OF DIRECT SUPPORT PEOPLE   7
NO. OF SUPERVISORS   1
+ NO. OF ADMINISTRATORS   1
------------------------------- ----
NO. OF PEOPLE   9

FACILITY

DIRECT SUPPORT PEOPLE X REQ. TECHNICAL SPACE/PERSON = REQ. WORKING SPACE
       7   X   275.   =   1925.00

(SUPERVSRS + ADMNSTRTRS) X REQ. SUPERVISORY SPACE/PERSON = ADDITIONAL SPACE
(1 + 1).X   130.   =   260.00

REQUIRED WORKING SPACE + ADDITIONAL SPACE = TOTAL SPACE
    1925.00   +   260.00   = 2185.00

TOTAL SPACE X COST/SQUARE FOOT = FACILITY COST
  2185.00 X   136.00   =   297160.

FACILITY COST / EXPECTED SYSTEM LIFE = ANNUAL FACILITY COST
    297160. /   10   =   29716.

UTILITIES

TOTAL SPACE X COST/SQUARE FOOT = UTILITY COST
  2185.00 X   1.20   =   2622.

APPENDIX H

F - 111F

(OFP) NAVIGATION WEAPON DELIVERY

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981$)
HISTORICAL SYSTEM
YEAR 1981

FURNISHINGS

 TOTAL PERSONS X INITIAL COST/PERSON = INITIAL FURNISHINGS COST
    9 X   680. =   6120.

 INITIAL FURNISHINGS COST / EXPECTED SYSTEM LIFE = ANNUAL FURNISHINGS COST
    6120.   /   10 =   612.

MATERIALS AND SUPPLIES

 TOTAL PERSONS X COST/PERSON = MATERIALS & SUPPLIES COST
    9 X 700. =   6300.

COMPUTERS/TERMINALS

 NO. DIRECT SUPPORT PEOPLE X INITIAL COST/PERSON = INITIAL COMP TERM COST
    7   X 20000. =   140000.

 INITIAL COMP TERM COST / EXPECTED SYSTEM LIFE = ANNUAL COMP TERM COST
    140000. /   10 =   14000.

HARDWARE MAINTENANCE

 HARDWARE COST (1981$) X MAINTENANCE RATIO = ANNUAL HARDWARE MAINTENANCE COS
   50791000.   X 0.10 =   5079100.

GENERAL SUPPORT EQUIPMENT COST

  FACILITY COST   29716.
  UTILITY COST   2622.
  FURNISHINGS COST   612.
  MATERIALS & SUPPLIES COST 6300.
  COMPUTERS/TERMINALS COST 14000.
 • HARDWARE MAINTENANCE COST 5078100.
  ----------------------------------- -------------
  GENERAL SUPPORT EQUIPMENT COST 5131350.

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APPENDIX H

ALQ - 131

(EW) Jammer

Historical System

APPENDIX H

ALQ - 131

(EW) JAMMER

BREAK DOWN OF ANNUAL COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1981

TOTAL ANNUAL COST 831074.

TOTAL LABOR			
DIRECT LABOR		172956.	211064.
REQUIREMENTS REVIEW	11542.		
DESIGN	18694.		
DEVELOPMENT	18694.		
INTEGRATION	18694.		
TEST AND EVALUATION	47302.		
DOCUMENTATION	40150.		
REPRODUCTION/INSTALL	7152.		
SUPPORT SOFTWARE	10728.		
INDIRECT LABOR		38108.	
SUPERVISION	26823.		
ADMINISTRATION	11295.		
TOTAL SUPPORT EQUIPMENT			620010.
DIRECT		491526.	
HARDWARE	54600.		
SUPPORT SOFTWARE	249600.		
TEST AIRCRAFT TIME	187200.		
REPRODUCTION	1126.		
GENERAL		128484.	
FACILITY	9248.		
UTILITIES	1632.		
FURNISHINGS	204.		
MATERIALS & SUPPLIES	4200.		
COMPUTERS/TERMINALS	4000.		
HARDWARE MAINTENANCE	109200.		

APPENDIX H

ALQ - 131

(EW) JAMMER

DERIVATION OF DIRECT LABOR COSTS BY GRADE
HISTORICAL SYSTEM
YEAR 1981

PHASE	GRADE	NUMBER OF MANMONTHS	COST PER MANMONTH	COST PER GRADE	DIRECT LABOR COST
1. REQUIREMENTS REVEIW					11542.
	GS-12	2.00	3576.	7152.	
	GS-13	1.00	4390.	4390.	
2. DESIGN					18694.
	GS-12	4.00	3576.	14304.	
	GS-13	1.00	4390.	4390.	
3. DEVELOPMENT					18694.
	GS-12	4.00	3576.	14304.	
	GS-13	1.00	4390.	4390.	
4. INTEGRATION					18694.
	GS-12	4.00	3576.	14304.	
	GS-13	1.00	4390.	4390.	
5. TEST AND EVALUATION					47302.
	GS-12	12.00	3576.	42912.	
	GS-13	1.00	4390.	4390.	
6. DOCUMENTATION					40150.
	GS-12	10.00	3576.	35760.	
	GS-13	1.00	4390.	4390.	
7. REPRO/INSTALLATION					7152.
	GS-12	2.00	3576.	7152.	
8. SUPPORT SOFTWARE					10728.
	GS-12	3.00	3576.	10728.	
TOTAL		47.00	3638.	172956.	172956.

NOTE: ACTUAL BLOCK CHANGE LENGTH IS 12 MONTHS

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APPENDIX H

ALQ - 131

(EW) JAMMER

DERIVATION OF ANNUAL INDIRECT LABOR COSTS (1981$)
HISTORICAL SYSTEM
YEAR 1981

SUPERVISION

        DIRECT ANNUALIZED ON-SITE MANMONTHS X SUPERVISN RATIO = SUPERVISN MANMONTHS
                        47.00   X   0.13   =   6.11

        SUPERVISION MANMONTHS X COST/MANMONTH = SUPERVISION COST
                6.11   X   4390.   =   26823.

ADMINISTRATIVE

        DIRECT ANNUALIZED ON-SITE MANMONTHS X ADMNSTIVE RATIO = ADMNSTIVE MANMONTHS
                        47.00   X   0.13   =   6.11

        ADMNSTIVE MANMONTHS X COST/MANMONTH X ADM COMP-FACT = ADMNSTIVE COST
                6.11   X   1847.   X   1.000   =   11285.

TOTAL INDIRECT LABOR

        SUPERVISION + ADMINISTRATIVE = INDIRECT LABOR COSTS
           26823. +   11285.   =   38108.

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APPENDIX H

ALQ - 131

(EW) JAMMER

DERIVATION OF ANNUAL DIRECT SUPPORT EQUIPMENT COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1981

EQUIPMENT

	HARDWARE	SUPPORT SOFTWARE	TOTAL
INITIAL COST (1981S)	1092000.	4972000.	6064000.
COST (1981S)	1092000.	4972000.	6064000.
EXPECTED SYSTEM LIFE	20	20	20
ANNUAL EQUIPMENT COST	54600.	248600.	303200.

TEST AIRCRAFT/TIME

ANNUAL T&E MANMONTHS X 144 = ANNUAL T&E MANHOURS
    7.81   X 144 =   1872.00

ANNUAL T&E MANHOURS X T&E RATIO = TEST AIRCRAFT HOURS
    1872.00   X 0.050   =   93.60

TEST AIRCRAFT HOURS X COST/HOUR = ANNUAL AIRCRAFT/TIME COST
    93.60   X 2000.   =.   187200.

REPRODUCTION

NUMBER OF FIELDED SYSTEMS X MED REP-FACT X COST/REPRO = REPRODUCTION COST
        268   X   0.120   X   35.00   =   1126.

REPRODUCTION COST X 12 / BLOCK CHANGE LENGTH = ANNUAL REPRODUCTION COST
        1126.   X 12 /   12   =   1126.

DIRECT SUPPORT EQUIPMENT COSTS

DIRECT HARDWARE COST	54600.
DIRECT SOFTWARE COST	248600.
AIRCRAFT/TIME COST	187200.
+ REPRODUCTION COST	1126.
DIRECT SUPPORT EQUIPMENT COST	491526.

APPENDIX E

ALQ - 131

(E*) JAMMER

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981s)
HISTORICAL SYSTEM
YEAR 1981

PEOPLE REQUIRED

    REQUIRED ANNUAL ON-SITE MANMONTHS / 12 = NO. OF DIRECT SUPPORT PEOPLE
              47.00   / 12 =   4

    ANNUAL SUPERVISION MANMONTHS / 12 = NO. OF SUPERVISORS
          6.11   / 12 =   1

    ANNUAL ADMINISTRATIVE MANMONTHS / 12 = NO. OF ADMINISTRTRS
           6.11   / 12 =   1

    NO. OF DIRECT SUPPORT PEOPLE   4
    NO. OF SUPERVISORS   1
 + NO. OF ADMINISTRATORS   1

    NO. OF PEOPLE   6

FACILITY

    DIRECT SUPPORT PEOPLE X REQ. TECHNICAL SPACE/PERSON = REQ. WORKING SPACE
          4   X   275.   =   1100.00

    (SUPERVSRS + ADMNSTRTRS) X REQ. SUPERVISORY SPACE/PERSON = ADDITIONAL SPACE
    (1   +   1   ) X   130.   =   260.00

    REQUIRED WORKING SPACE + ADDITIONAL SPACE = TOTAL SPACE
       1100.00   +   260.00   =   1360.00

    TOTAL SPACE X COST/SQUARE FOOT = FACILITY COST
      1360.00   X   136.00   =   184960.

    FACILITY COST / EXPECTED SYSTEM LIFE = ANNUAL FACILITY COST
      184960.   /   20   =   9248.

UTILITIES

    TOTAL SPACE X COST/SQUARE FOOT = UTILITY COST
      1360.00   X   1.20   =   1632.

APPENDIX H

ALQ - 131

(EW) JAMMER

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981s)
HISTORICAL SYSTEM
YEAR 1981

FURNISHINGS

    TOTAL PERSONS X INITIAL COST/PERSON = INITIAL FURNISHINGS COST
          6   X   680.   =   4080.

    INITIAL FURNISHINGS COST / EXPECTED SYSTEM LIFE = ANNUAL FURNISHINGS COST
              4080.   /   20   =   204.

MATERIALS AND SUPPLIES

    TOTAL PERSONS X COST/PERSON = MATERIALS & SUPPLIES COST
          6   X   700.   =   4200.

COMPUTERS/TERMINALS

    NO. DIRECT SUPPORT PEOPLE X INITIAL COST/PERSON = INITIAL COMP TERM COST
              4   X   20000.   =   80000.

    INITIAL COMP TERM COST / EXPECTED SYSTEM LIFE = ANNUAL COMP TERM COST
              80000.   /   20   =   4000.

HARDWARE MAINTENANCE

    HARDWARE COST (1981s) X MAINTENANCE RATIO = ANNUAL HARDWARE MAINTENANCE COS
          1092000.   X   0.10   =   109200.

GENERAL SUPPORT EQUIPMENT COST

        FACILITY COST   9248.
        UTILITY COST   1632.
        FURNISHINGS COST   204.
        MATERIALS & SUPPLIES COST   4200.
        COMPUTERS/TERMINALS COST   4000.
    +   HARDWARE MAINTENANCE COST   109200.
    ------------------------------------   ------------
        GENERAL SUPPORT EQUIPMENT COST   128484.

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APPENDIX H

F-16 FCC

(OFP) Fire Control

Historical System

APPENDIX H

F-16 FCC

(OFP) FIRE CONTROL

BREAK DOWN OF ANNUAL COSTS (1981$)
HISTORICAL SYSTEM
YEAR 1981

TOTAL ANNUAL COST   2339587.

TOTAL LABOR			402587.
DIRECT LABOR		326371.	
REQUIREMENTS REVIEW	57715.		
DESIGN	48988.		
DEVELOPMENT	38643.		
INTEGRATION	21189.		
TEST AND EVALUATION	45029.		
DOCUMENTATION	26816.		
REPRODUCTION/INSTALL	1668.		
SUPPORT SOFTWARE	86323.		
INDIRECT LABOR		76216.	
SUPERVISION	53646.		
ADMINISTRATION	22570.		
TOTAL SUPPORT EQUIPMENT			1937000.
DIRECT		788493.	
HARDWARE	447400.		
SUPPORT SOFTWARE	223720.		
TEST AIRCRAFT TIME	109440.		
REPRODUCTION	7933.		
GENERAL		1148506.	
FACILITY	13382.		
UTILITIES	2952.		
FURNISHINGS	272.		
MATERIALS & SUPPLIES	7000.		
COMPUTERS/TERMINALS	6400.		
HARDWARE MAINTENANCE	1118500.		

APPENDIX H

F-16 FCC

(OFP) FIRE CONTROL

DEPIVATION OF DIRECT LABOR COSTS BY GRADE
HISTORICAL SYSTEM
YEAR 1981

PHASE	GRADE	NUMBER OF MANMONTHS	COST PER MANMONTH	COST PER GRADE	DIRECT LABOR COST
1. REQUIREMENTS REVEIW					57715.
	GS-11	4.00	2969.	11876.	
	GS-12	12.00	3576.	42912.	
	GS-13	0.67	4390.	2927.	
2. DESIGN					48988.
	GS-11	2.67	2969.	7917.	
	GS-12	10.67	3576.	38144.	
	GS-13	0.67	4390.	2927.	
3. DEVELOPMENT					38643.
	GS-11	4.00	2969.	11876.	
	GS-12	6.67	3576.	23840.	
	GS-13	0.67	4390.	2927.	
4. INTEGRATION					21189.
	GS-11	1.33	2969.	3959.	
	GS-12	4.00	3576.	14304.	
	GS-13	0.67	4390.	2927.	
5. TEST AND EVALUATION					45029.
	GS-11	1.33	2969.	3959.	
	GS-12	10.67	3576.	38144.	
	GS-13	0.67	4390.	2927.	
6. DOCUMENTATION					26816.
	GS-9	0.67	2502.	1668.	
	GS-11	2.67	2969.	7917.	
	GS-12	4.00	3576.	14304.	
	GS-13	0.67	4390.	2927.	
7. REPPG/INSTALLATION					1668.
	GS-9	0.67	2502.	1668.	
8. SUPPORT SOFTWARE					86323.
	GS-11	4.00	2969.	11876.	
	GS-12	20.00	3576.	71520.	
	GS-13	0.67	4390.	2927.	
TOTAL		94.00	3325.	326371.	326371.

NOTE: ACTUAL BLOCK CHANGE LENGTH IS 18 MONTHS

APPENDIX H

F-16 FCC

(OFP) FIRE CONTROL

DERIVATION OF ANNUAL INDIRECT LABOR COSTS (1981$)
HISTORICAL SYSTEM
YEAR 1981

SUPERVISION

DIRECT ANNUALIZED ON-SITE MANMONTHS X SUPERVISN RATIO = SUPERVISN MANMONTHS
        94.00   X   0.13   =   12.22

SUPERVISION MANMONTHS X COST/MANMONTH = SUPERVISION COST
     12.22   X   4390.   =   53646.

ADMINISTRATIVE

DIRECT ANNUALIZED ON-SITE MANMONTHS X ADMNSTIVE RATIO = ADMNSTIVE MANMONTHS
        94.00   X   0.13   =   12.22

ADMNSTIVE MANMONTHS X COST/MANMONTH X ADM COMP-FACT = ADMNSTIVE COST
     12.22   X   1847.   X   1.000   =   22570.

TOTAL INDIRECT LABOR

SUPERVISION + ADMINISTRATIVE = INDIRECT LABOR COSTS
  53646.   +   22570.   =   76216.

APPENDIX H

F-16 FCC

(OFP) FIRE CONTROL

DERIVATION OF ANNUAL DIRECT SUPPORT EQUIPMENT COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1981

EQUIPMENT

	HARDWARE	SUPPORT SOFTWARE	TOTAL
INITIAL COST (1981S)	11185000.	5593000.	16778000.
COST (1981S)	11195000.	5593000.	16778000.
EXPECTED SYSTEM LIFE	25	25	25
ANNUAL EQUIPMENT COST	447400.	223720.	671120.

TEST AIRCRAFT/TIME

ANNUAL T&E MANMONTHS X 144 = ANNUAL T&E MANHOURS
      18.25   X 144 =   1824.00

ANNUAL T&E MANHOURS X T&E RATIO = TEST AIRCRAFT HOURS
     1824.00   X   0.030   =   54.72

TEST AIRCRAFT HOURS X COST/HOUR = ANNUAL AIRCRAFT/TIME COST
     54.72   X   2000.   =   109440.

REPRODUCTION

NUMBER OF FIELDED SYSTEMS X MED REP-FACT X COST/REPRO = REPRODUCTION COS'
          350   X   2.000   X   17.00   =   11900.

REPRODUCTION COST X 12 / BLOCK CHANGE LENGTH = ANNUAL REPRODUCTION COST
     11900.   X 12 /   18   =   7933.

DIRECT SUPPORT EQUIPMENT COSTS

DIRECT HARDWARE COST	447400.
DIRECT SOFTWARE COST	223720.
AIRCRAFT/TIME COST	109440.
+ REPRODUCTION COST	7933.
DIRECT SUPPORT EQUIPMENT COST	788493.

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APPENDIX H

F-16 FCC

(OFP) FIRE CONTROL

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1981

PEOPLE REQUIRED

REQUIRED ANNUAL ON-SITE MANMONTHS / 12 = NO. OF DIRECT SUPPORT PEOPLE
            94.00   / 12 =   8

ANNUAL SUPERVISION MANMONTHS / 12 = NO. OF SUPERVISORS
        12.22   / 12 =   1

ANNUAL ADMINISTRATIVE MANMONTHS / 12 = NO. OF ADMINISTRTRS
            12.22   / 12 =   1

    NO. OF DIRECT SUPPORT PEOPLE   8
    NO. OF SUPERVISORS   1
  + NO. OF ADMINISTRATORS   1
    ---------------------------------- -----
    NO. OF PEOPLE   10

FACILITY

    DIRECT SUPPORT PEOPLE X REQ. TECHNICAL SPACE/PERSON = REQ. WORKING SPACE
            8   X   275.   =   2200.00

    (SUPERVSRS + ADMNSTRTRS) X REQ. SUPERVISORY SPACE/PERSON = ADDITIONAL SPAC
    (1   +   1   ) X   130.   =   260.00

    REQUIRED WORKING SPACE + ADDITIONAL SPACE = TOTAL SPACE
        2200.00   +   260.00   =   2460.00

    TOTAL SPACE X COST/SQUARE FOOT = FACILITY COST
      2460.00   X   136.00   =   334560.

    FACILITY COST / EXPECTED SYSTEM LIFE = ANNUAL FACILITY COST
        334560. /   25   =   13382.

UTILITIES

    TOTAL SPACE X COST/SQUARE FOOT = UTILITY COST
      2460.00   X   1.20   =   2952.

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APPENDIX H

F-16 FCC

(OFP) FIRE CONTROL

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981s)
HISTORICAL SYSTEM
YEAR 1981

FURNISHINGS

    TOTAL PERSONS X INITIAL COST/PERSON = INITIAL FURNISHINGS COST
         10   X   680.   =   6800.

    INITIAL FURNNISHINGS COST / EXPECTED SYSTEM LIFE = ANNUAL FURNISHINGS COST
            6800.   /   25   =   272.

MATERIALS AND SUPPLIES

    TOTAL PERSONS X COST/PERSON = MATERIALS & SUPPLIES COST
         10   X   700.   =   7000.

COMPUTERS/TERMINALS

    NO. DIRECT SUPPORT PEOPLE X INITIAL COST/PERSON = INITIAL COMP TERM COST
              8   X   20000.   =   160000.

    INITIAL COMP TERM COST / EXPECTED SYSTEM LIFE = ANNUAL COMP TERM COST
           160000.   /   25   =   6400.

HARDWARE MAINTENANCE

    HARDWARE COST (1981s) X MAINTENANCE RATIO = ANNUAL HARDWARE MAINTENANCE COS
         11185000.   X   0.10   =   1118500.

GENERAL SUPPORT EQUIPMENT COST

        FACILITY COST   13382.
        UTILITY COST   2952.
        FURNISHINGS COST   272.
        MATERIALS & SUPPLIES COST   7000.
        COMPUTERS/TERMINALS COST   6400.
      + HARDWARE MAINTENANCE COST   1118500.
        ------------------------------------ ------------
        GENERAL SUPPORT EQUIPMENT COST   1148506.

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APPENDIX H

ALR - 62

(EW) Receiver

Historical System

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APPENDIX H

ALR - 62

(EW) RECEIVER

BREAK DOWN OF ANNUAL COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1981

TOTAL ANNUAL COST   1161813.

TOTAL LABOR			254877.
DIRECT LABOR		217256.	
REQUIREMENTS REVIEW	7152.		
DESIGN	53150.		
DEVELOPMENT	54997.		
INTEGRATION	31998.		
TEST AND EVALUATION	17846.		
DOCUMENTATION	17846.		
REPRODUCTION/INSTALL	5423.		
SUPPORT SOFTWARE	28844.		
INDIRECT LABOR		37621.	
SUPERVISION	25682.		
ADMINISTRATION	11939.		
TOTAL SUPPORT EQUIPMENT			906936.
DIRECT		708800.	
HARDWARE	165400.		
SUPPORT SOFTWARE	101800.		
TEST AIRCRAFT TIME	72000.		
REPRODUCTION	369600.		
GENERAL		198136.	
FACILITY	19496.		
UTILITIES	1632.		
FURNISHINGS	408.		
MATERIALS & SUPPLIES	4200.		
COMPUTERS/TERMINALS	9000.		
HARDWARE MAINTENANCE	165400.		

APPENDIX H

ALR - 62

(EW) RECEIVER

DERIVATION OF DIRECT LABOR COSTS BY GRADE
HISTORICAL SYSTEM
YEAR 1981

PHASE	GRADE	NUMBER OF MANMONTHS	COST PER MANMONTH	COST PER GRADE	DIRECT LABOR COST
1. REQUIREMENTS REVEIW					7152.
	GS-12	2.00	3576.	7152.	
2. DESIGN					53150.
	GS-7	2.00	1847.	3694.	
	GS-12	6.00	3576.	21456.	
	CNTR	4.00	7000.	28000.	
3. DEVELOPMENT					54997.
	GS-7	3.00	1847.	5541.	
	GS-12	6.00	3576.	21456.	
	CNTR	4.00	7000.	28000.	
4. INTEGRATION					31998.
	GS-7	2.00	1847.	3694.	
	GS-12	4.00	3576.	14304.	
	CNTR	2.00	7000.	14000.	
5. TEST AND EVALUATION					17846.
	GS-7	2.00	1847.	3694.	
	GS-12	2.00	3576.	7152.	
	CNTR	1.00	7000.	7000.	
6. DOCUMENTATION					17846.
	GS-7	2.00	1847.	3694.	
	GS-12	2.00	3576.	7152.	
	CNTR	1.00	7000.	7000.	
7. REPRO/INSTALLATION					5423.
	GS-7	1.00	1847.	1847.	
	GS-12	1.00	3576.	3576.	
8. SUPPORT SOFTWARE					28844.
	GS-7	4.00	1847.	7388.	
	GS-12	6.00	3576.	21456.	
TOTAL		57.00	3844.	217256.	217256.

NOTE: ACTUAL BLOCK CHANGE LENGTH IS 12 MONTHS

APPENDIX H

ALR - 62

(EJ) RECEIVER

DERIVATION OF ANNUAL INDIRECT LABOR COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1981

SUPERVISION

DIRECT ANNUALIZED ON-SITE MANMONTHS X SUPERVISN RATIO = SUPERVISN MANMONTHS
            45.00   X   0.13   =   5.85

SUPERVISION MANMONTHS X COST/MANMONTH = SUPERVISION COST
       5.85   X   4390.   =   25682.

ADMINISTRATIVE

DIRECT ANNUALIZED ON-SITE MANMONTHS X ADMNSTIVE RATIO = ADMNSTIVE MANMONTHS
            45.00   X   0.13   =   5.85

ADMNSTIVE MANMONTHS X COST/MANMONTH X ADM COMP-FACT = ADMNSTIVE COST
       5.85   X   1847.   X   1.105   =   11939.

TOTAL INDIRECT LABOR

SUPERVISION + ADMINISTRATIVE = INDIRECT LABOR COSTS
    25682.   +   11939.   =   37621.

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APPENDIX H

ALR - 62

(EW) RECEIVER

DERIVATION OF ANNUAL DIRECT SUPPORT EQUIPMENT COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1981

EQUIPMENT

	HARDWARE	SUPPORT SOFTWARE	TOTAL
INITIAL COST (1981S)	1654000.	1018000.	2672000.
COST (1981S)	1654000.	1018000.	2672000.
EXPECTED SYSTEM LIFE	10	10	10
ANNUAL EQUIPMENT COST	165400.	101800.	267200.

TEST AIRCRAFT/TIME

ANNUAL T&E MANMONTHS X 144 = ANNUAL T&E MANHOURS
      2.21   X 144 =   720.00

ANNUAL T&E MANHOURS X T&E RATIO = TEST AIRCRAFT HOURS
     720.00   X   0.050   =   36.00

TEST AIRCRAFT HOURS X COST/HOUR = ANNUAL AIRCRAFT/TIME COST
     36.00   X   2000.   =   72000.

REPRODUCTION

NUMBER OF FIELDED SYSTEMS X MED REP-FACT X COST/REPRO = REPRODUCTION COST
        300   X   61.600   X   20.00   =   369600.

REPRODUCTION COST X 12 / BLOCK CHANGE LENGTH = ANNUAL REPRODUCTION COST
     369600.   X 12 /   12   =   369600.

DIRECT SUPPORT EQUIPMENT COSTS

DIRECT HARDWARE COST	165400.
DIRECT SOFTWARE COST	101800.
AIRCRAFT/TIME COST	72000.
+ REPRODUCTION COST	369600.
DIRECT SUPPORT EQUIPMENT COST	708800.

APPENDIX H

ALR - 62

(EW) RECEIVER

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981s)
HISTORICAL SYSTEM
YEAR 1981

PEOPLE REQUIRED

    REQUIRED ANNUAL ON-SITE MANMONTHS / 12 = NO. OF DIRECT SUPPORT PEOPLE
                   45.00   / 12 =   4

    ANNUAL SUPERVISION MANMONTHS / 12 = NO. OF SUPERVISORS
                5.85   / 12 =   1

    ANNUAL ADMINISTRATIVE MANMONTHS / 12 = NO. OF ADMINISTRTRS
                 5.85   / 12 =   1

    NO. OF DIRECT SUPPORT PEOPLE   4
    NO. OF SUPERVISORS   1
  + NO. OF ADMINISTRATORS   1
    ------------------------------ ----
    NO. OF PEOPLE   6

FACILITY

    DIRECT SUPPORT PEOPLE X REQ. TECHNICAL SPACE/PERSON = REQ. WORKING SPACE
              4   X   275.   =   1100.00

    (SUPERVSRS + ADMNSTRTRS) X REQ. SUPERVISORY SPACE/PERSON = ADDITIONAL SPACE
    (1   +   1   ) X   130.   =   260.00

    REQUIRED WORKING SPACE + ADDITIONAL SPACE = TOTAL SPACE
          1100.00   +   260.00   =   1360.00

    TOTAL SPACE X COST/SQUARE FOOT = FACILITY COST
       1360.00 X   136.00   =   184960.

    FACILITY COST / EXPECTED SYSTEM LIFE = ANNUAL FACILITY COST
        184960. /   10   =   18496.

UTILITIES

    TOTAL SPACE X COST/SQUARE FOOT = UTILITY COST
       1360.00 X   1.20   =   1632.

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APPENDIX H

ALR - 62

(EW) RECEIVER

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981$)
HISTORICAL SYSTEM
YEAR 1981

FURNISHINGS

```
TOTAL PERSONS X INITIAL COST/PERSON = INITIAL FURNISHINGS CUST
      6         X          680.      =         4080.
```

```
INITIAL FURNISHINGS COST / EXPECTED SYSTEM LIFE = ANNUAL FURNISHINGS COST
          4080.               /           10        =          408.
```

MATERIALS AND SUPPLIES

```
TCTAL PERSONS X COST/PERSON = MATERIALS & SUPPLIES COST
      6         X     700.   =         4200.
```

COMPUTERS/TERMINALS

```
NO. DIRECT SUPPORT PEOPLE X INITIAL COST/PERSON = INITIAL COMP TERM COST
             4            X       20000.      =        80000.
```

```
INITIAL COMP TERM COST / EXPECTED SYSTEM LIFE = ANNUAL COMP TERM COST
          80000.          /           10        =         8000.
```

HARDWARE MAINTENANCE

```
HARDWARE COST (1981$) X MAINTENANCE RATIO = ANNUAL HARDWARE MAINTENANCE COS
        1654000.        X         0.10      =         165400.
```

GENERAL SUPPORT EQUIPMENT COST

```
    FACILITY COST                     18496.
    UTILITY COST                       1632.
    FURNISHINGS COST                    408.
    MATERIALS & SUPPLIES COST          4200.
    COMPUTERS/TERMINALS COST           8000.
  + HARDWARE MAINTENANCE COST        165400.
    ----------------------------   -----------
    GENERAL SUPPORT EQUIPMENT COST   198136.
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APPENDIX H

APR - 38

(EW) Integrated System

Historical System

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APPENDIX H

APR - 38

(Ew) INTEGRATED SYSTEM

BREAK DOWN OF ANNUAL COSTS (1981s)
HISTORICAL SYSTEM
YEAR 1981

TOTAL ANNUAL COST   2412920.

TOTAL LABOR			288783.
DIRECT LABOR		227972.	
REQUIREMENTS REVIEW	21670.		
DESIGN	37869.		
DEVELOPMENT	34293.		
INTEGRATION	38336.		
TEST AND EVALUATION	64079.		
DOCUMENTATION	31725.		
REPRODUCTION/INSTALL	0.		
SUPPORT SOFTWARE	0.		
INDIRECT LABOR		60811.	
SUPERVISION	42803.		
ADMINISTRATION	18008.		
TOTAL SUPPORT EQUIPMENT			2124137.
DIRECT		1644787.	
HARDWARE	426100.		
SUPPORT SOFTWARE	426200.		
TEST AIRCRAFT TIME	792000.		
REPRODUCTION	487.		
GENERAL		479350.	
FACILITY	29716.		
UTILITIES	2622.		
FURNISHINGS	612.		
MATERIALS & SUPPLIES	6300.		
COMPUTERS/TERMINALS	14000.		
HARDWARE MAINTENANCE	426100.		

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APPENDIX H

APR - 38

(EW) INTEGRATED SYSTEM

DERIVATION OF DIRECT LABOR COSTS BY GRADE
HISTORICAL SYSTEM
YEAR 1981

PHASE	GRADE	NUMBER OF MANMONTHS	COST PER MANMONTH	COST PER GRADE	DIRECT LABOR COST
1. REQUIREMENTS REVEIW					21670.
	GS-9	2.00	2502.	5004.	
	GS-11	2.00	2969.	5938.	
	GS-12	3.00	3576.	10728.	
2. DESIGN					37869.
	GS-9	3.00	2502.	7506.	
	GS-11	3.00	2969.	8907.	
	GS-12	6.00	3576.	21456.	
3. DEVELOPMENT					34293.
	GS-9	3.00	2502.	7506.	
	GS-11	3.00	2969.	8907.	
	GS-12	5.00	3576.	17880.	
4. INTEGRATION					38336.
	GS-9	2.00	2502.	5004.	
	GS-11	4.00	2969.	11876.	
	GS-12	6.00	3576.	21456.	
5. TEST AND EVALUATION					64079.
	GS-9	6.00	2502.	15012.	
	GS-11	3.00	2969.	8907.	
	GS-12	9.00	3576.	32184.	
	O-1	4.00	1994.	7976.	
6. DOCUMENTATION					31725.
	GS-9	2.00	2502.	5004.	
	GS-11	9.00	2969.	26721.	
7. REPRO/INSTALLATION					0.
8. SUPPORT SOFTWARE					0.
TOTAL		75.00	3005.	227972.	227972.

NOTE: ACTUAL BLOCK CHANGE LENGTH IS 12 MONTHS

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APPENDIX H

APR - 38

(EW) INTEGRATED SYSTEM

DERIVATION OF ANNUAL INDIRECT LABOR COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1981

SUPERVISION
━━━━━━━━━━━

DIRECT ANNUALIZED ON-SITE MANMONTHS X SUPERVISN RATIO = SUPERVISN MANMONTHS
              75.00   X   0.13   =   9.75

SUPERVISION MANMONTHS X COST/MANMONTH = SUPERVISION COST
        9.75   X   4390.   =   42803.

ADMINISTRATIVE
━━━━━━━━━━━━━━

DIRECT ANNUALIZED ON-SITE MANMONTHS X ADMNSTIVE RATIO = ADMNSTIVE MANMONTHS
              75.00   · X   0.13   =   9.75

ADMNSTIVE MANMONTHS X COST/MANMONTH X ADM COMP-FACT = ADMNSTIVE COST
      9.75   X   1847.   X   1.000   =   18008.

TOTAL INDIRECT LABOR
━━━━━━━━━━━━━━━━━━━━

SUPERVISION + ADMINISTRATIVE = INDIRECT LABOR COSTS
   42803.   +   18008.   =   60811.

APPENDIX H

APR - 38

(EA) INTEGRATED SYSTEM

DERIVATION OF ANNUAL DIRECT SUPPORT EQUIPMENT COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1981

EQUIPMENT

	HARDWARE	SUPPORT SOFTWARE	TOTAL
INITIAL COST (1981S)	4261000.	4262000.	8523001.
COST (1981S)	4261000.	4262000.	8523001.
EXPECTED SYSTEM LIFE	10	10	10
ANNUAL EQUIPMENT COST	426100.	426200.	852300.

TEST AIRCRAFT/TIME

ANNUAL T&E MANMONTHS X 144 = ANNUAL T&E MANHOURS
       16.58   X 144 =   3168.00

ANNUAL T&E MANHOURS X T&E RATIO = TEST AIRCRAFT HOURS
     3168.00   X 0.050   =   158.40

TEST AIRCRAFT HOURS X COST/HOUR = ANNUAL AIRCRAFT/TIME COST
     158.40   X   5000. =.   792000.

REPRODUCTION

NUMBER OF FIELDED SYSTEMS X MED REP-FACT X COST/REPRO = REPRODUCTION COST
       116   X   0.120   X   35.00   =   487.

REPRODUCTION COST X 12 / BLOCK CHANGE LENGTH = ANNUAL REPRODUCTION COST
     487.   X 12 /   12   =   487.

DIRECT SUPPORT EQUIPMENT COSTS

DIRECT HARDWARE COST	426100.
DIRECT SOFTWARE COST	426200.
AIRCRAFT/TIME COST	792000.
+ REPRODUCTION COST	487.
DIRECT SUPPORT EQUIPMENT COST	1644787.

APPENDIX H

APR - 38

(EW) INTEGRATED SYSTEM

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981s)
HISTORICAL SYSTEM
YEAR 1981

PEOPLE REQUIRED

REQUIRED ANNUAL ON-SITE MANMONTHS / 12 = NO. OF DIRECT SUPPORT PEOPLE
75.00   / 12 =   7

ANNUAL SUPERVISION MANMONTHS / 12 = NO. OF SUPERVISORS
9.75   / 12 =   1

ANNUAL ADMINISTRATIVE MANMONTHS / 12 = NO. OF ADMINISTRTRS
9.75   / 12 =   1

NO. OF DIRECT SUPPORT PEOPLE   7
NO. OF SUPERVISORS   1
+ NO. OF ADMINISTRATORS   1
----------------------------------- ----
NO. OF PEOPLE   9

FACILITY

DIRECT SUPPORT PEOPLE X REQ. TECHNICAL SPACE/PERSON = REQ. WORKING SPACE
7   X   275.   =   1925.00

(SUPERVSRS + ADMNSTRTRS) X REQ. SUPERVISORY SPACE/PERSON = ADDITIONAL SPACE
(1   +   1   ) X   130.   =   260.00   -

REQUIRED WORKING SPACE + ADDITIONAL SPACE = TOTAL SPACE
1925.00   +   260.00   =   2185.00

TOTAL SPACE X COST/SQUARE FOOT = FACILITY COST
2185.00   X   136.00   =   297160.

FACILITY COST / EXPECTED SYSTEM LIFE = ANNUAL FACILITY COST
297160.   /   10   =   29716.

UTILITIES

TOTAL SPACE X COST/SQUARE FOOT = UTILITY COST
2185.00   X   1.20   =   2622.

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APPENDIX H

APR - 38

(EW) INTEGRATED SYSTEM

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1981

FURNISHINGS

    TOTAL PERSONS X INITIAL COST/PERSON = INITIAL FURNISHINGS COST
         9   X   680.   =   6120.

    INITIAL FURNRISHINGS COST / EXPECTED SYSTEM LIFE = ANNUAL FURNISHINGS COST
            6120.   /   10   =   612.

MATERIALS AND SUPPLIES

    TOTAL PERSONS X COST/PERSON = MATERIALS & SUPPLIES COST
         9   X   700.   =   6300.

COMPUTERS/TERMINALS

    NO. DIRECT SUPPORT PEOPLE X INITIAL COST/PERSON = INITIAL COMP TERM COST
             7   X   20000.   =   140000.

    INITIAL COMP TERM COST / EXPECTED SYSTEM LIFE = ANNUAL COMP TERM COST
           140000.   /   10   =   14000.

HARDWARE MAINTENANCE

    HARDWARE COST (1981S) X MAINTENANCE RATIO = ANNUAL HARDWARE MAINTENANCE COS
          4261000.   X   0.10   =   426100.

GENERAL SUPPORT EQUIPMENT COST

        FACILITY COST   29716.
        UTILITY COST   2622.
        FURNISHINGS COST   612.
        MATERIALS & SUPPLIES COST   6300.
        COMPUTERS/TERMINALS COST   14000.
      + HARDWARE MAINTENANCE COST   426100.
        ------------------------------- -----------
        GENERAL SUPPORT EQUIPMENT COST 479350.

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APPENDIX H

A - 7

(OFP) Navigation Fire Control Weapon Delivery

Historical System

APPENDIX H

A - 7

(OFP) NAVIGATION FIRE CONTROL WEAPON DELIVERY

BREAK DOWN OF ANNUAL COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1981

TOTAL ANNUAL COST   574237.

TOTAL LABOR			321880.
DIRECT LABOR		275632.	
REQUIREMENTS REVIEW	45846.		
DESIGN	37078.		
DEVELOPMENT	38552.		
INTEGRATION	17959.		
TEST AND EVALUATION	48541.		
DOCUMENTATION	34759.		
REPRODUCTION/INSTALL	3002.		
SUPPORT SOFTWARE	49894.		
INDIRECT LABOR		46248.	
SUPERVISION	31845.		
ADMINISTRATION	14403.		
TOTAL SUPPORT EQUIPMENT			252357.
DIRECT		163139.	
HARDWARE	33000.		
SUPPORT SOFTWARE	10000.		
TEST AIRCRAFT TIME	119232.		
REPRODUCTION	907.		
GENERAL		89218.	
FACILITY	11118.		
UTILITIES	1962.		
FURNISHINGS	238.		
MATERIALS & SUPPLIES	4900.		
COMPUTERS/TERMINALS	5000.		
HARDWARE MAINTENANCE	66000.		

APPENDIX H

A - 7

(OFP) NAVIGATION FIRE CONTROL WEAPON DELIVERY

DERIVATION OF DIRECT LABOR COSTS BY GRADE
HISTORICAL SYSTEM
YEAR 1981

PHASE	GRADE	NUMBER OF MANMONTHS	COST PER MANMONTH	COST PER GRADE	DIRECT LABOR COST
1. REQUIREMENTS REVEIW					45846.
	GS-12	3.00	3576.	10728.	
	GS-13	3.00	4390.	13170.	
	O-4	3.00	4516.	13548.	
	CNTR	1.20	7000.	8400.	
2. DESIGN					37078.
	GS-12	3.60	3576.	12874.	
	GS-13	3.60	4390.	15804.	
	CNTR	1.20	7000.	8400.	
3. DEVELOPMENT					38552.
	GS-12	2.40	3576.	8582.	
	GS-13	3.00	4390.	13170.	
	CNTR	2.40	7000.	16800.	
4. INTEGRATION					17959.
	GS-12	1.20	3576.	4291.	
	GS-13	1.20	4390.	5268.	
	CNTR	1.20	7000.	8400.	
5. TEST AND EVALUATI					48541.
	GS-9	3.00	2502.	7506.	
	GS-12	3.00	3576.	10728.	
	GS-13	3.00	4390.	13170.	
	O-1	1.80	1994.	3589.	
	O-4	3.00	4516.	13548.	
6. DOCUMENTATION					34759.
	GS-12	1.20	3576.	4291.	
	GS-13	1.20	4390.	5268.	
	CNTR	3.60	7000.	25200.	
7. REPRO/INSTALLATION					3002.
	GS-9	1.20	2502.	3002.	
8. SUPPORT SOFTWARE					49894.
	GS-9	2.40	2502.	6005.	
	GS-12	10.80	3576.	38621.	
	GS-13	1.20	4390.	5268.	
TOTAL		65.40	4142.	275632.	275632.

NOTE: ACTUAL BLOCK CHANGE LENGTH IS 20 MONTHS

APPENDIX H

A - 7

(OFP) NAVIGATION FIRE CONTROL WEAPON DELIVERY

DERIVATION OF ANNUAL INDIRECT LABOR COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1981

SUPERVISION

DIRECT ANNUALIZED ON-SITE MANMONTHS X SUPERVISN RATIO = SUPERVISN MANMONTH:
             55.80   X   0.13   =   7.25

SUPERVISION MANMONTHS X COST/MANMONTH = SUPERVISION COST
      7.25   X   4390.   =   31845.

ADMINISTRATIVE

DIRECT ANNUALIZED ON-SITE MANMONTHS X ADMNSTIVE RATIO = ADMNSTIVE MANMONTHS
             55.80   X   0.13   =   7.25

ADMNSTIVE MANMONTHS X COST/MANMONTH X ADM COMP-FACT = ADMNSTIVE COST
      7.25   X   1847.   X   1.075   =   14403.

TOTAL INDIRECT LABOR

SUPERVISION + ADMINISTRATIVE = INDIRECT LABOR COSTS
   31845. +   14403.   =   46249.
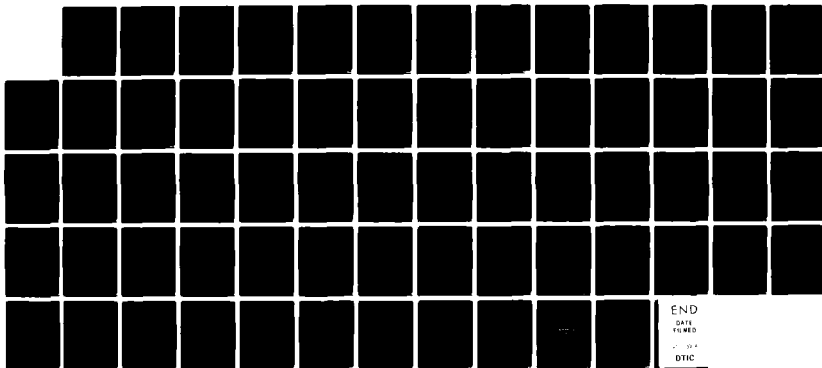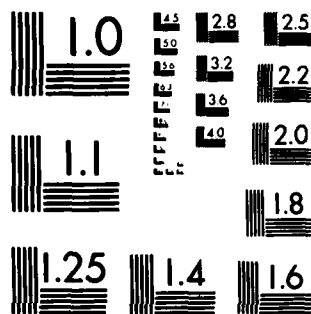
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

APPENDIX H

A - 7

(OFP) NAVIGATION FIRE CONTROL WEAPON DELIVERY

DERIVATION OF ANNUAL DIRECT SUPPORT EQUIPMENT COSTS (1981$)
HISTORICAL SYSTEM
YEAR 1981

EQUIPMENT

	HARDWARE	SUPPORT SOFTWARE	TOTAL
INITIAL COST (1981$)	660000.	200000.	860000.
COST (1981$)	660000.	200000.	860000.
EXPECTED SYSTEM LIFE	20	20	20
ANNUAL EQUIPMENT COST	33000.	10000.	43000.

TEST AIRCRAFT/TIME

ANNUAL T&E MANMONTHS X 144 = ANNUAL T&E MANHOURS
      10.23   X 144 =   1987.20

ANNUAL T&E MANHOURS X T&E RATIO = TEST AIRCRAFT HOURS
      1987.20   X 0.030   =   59.62

TEST AIRCRAFT HOURS X COST/HOUR = ANNUAL AIRCRAFT/TIME COST
      59.62   X   2000. =   119232.

REPRODUCTION

NUMBER OF FIELDED SYSTEMS X MED REP-FACT X COST/REPRO = REPRODUCTION COST
      360   X   0.120   X   35.00   =   1512.

REPRODUCTION COST X 12 / BLOCK CHANGE LENGTH = ANNUAL REPRODUCTION COST
      1512.   X 12 /   20   =   907.

DIRECT SUPPORT EQUIPMENT COSTS

DIRECT HARDWARE COST	33000.
DIRECT SOFTWARE COST	10000.
AIRCRAFT/TIME COST	119232.
+ REPRODUCTION COST	907.
DIRECT SUPPORT EQUIPMENT COST	163139.

APPENDIX H

A - 7

(OFP) NAVIGATION FIRE CONTROL WEAPON DELIVERY

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981$)
HISTORICAL SYSTEM
YEAR 1981

PEOPLE REQUIRED

    REQUIRED ANNUAL ON-SITE MANMONTHS / 12 = NO. OF DIRECT SUPPORT PEOPLE
           55.80   / 12 =   5

    ANNUAL SUPERVISION MANMONTHS / 12 = NO. OF SUPERVISORS
         7.25   / 12 =   1

    ANNUAL ADMINISTRATIVE MANMONTHS / 12 = NO. OF ADMINISTRTRS
         7.25   / 12 =   1

    NO. OF DIRECT SUPPORT PEOPLE   5
    NO. OF SUPERVISORS   1
+ NO. OF ADMINISTRATORS   1
    -------------------------------- ----
    NO. OF PEOPLE   7

FACILITY

    DIRECT SUPPORT PEOPLE X REQ. TECHNICAL SPACE/PERSON = REQ. WORKING SPACE
         5   X   275.   =   1375.00

    (SUPERVSRS + ADMNSTRTRS) X REQ. SUPERVISORY SPACE/PERSON = ADDITIONAL SPA
    (1   +   1   ) X   130.   =   260.00

    REQUIRED WORKING SPACE + ADDITIONAL SPACE = TOTAL SPACE
      1375.00   +   260.00   = 1635.00

    TOTAL SPACE X COST/SQUARE FOOT = FACILITY COST
     1635.00   X   136.00   =   222360.

    FACILITY COST / EXPECTED SYSTEM LIFE = ANNUAL FACILITY COST
     222360. /   20   =   11118.

UTILITIES

    TOTAL SPACE X COST/SQUARE FOOT = UTILITY COST
     1635.00   X   1.20   =   1962.

APPENDIX H

A - 7

(OFP) NAVIGATION FIPE CONTROL WEAPON DELIVERY

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1981

FURNISHINGS

    TOTAL PERSONS X INITIAL COST/PERSON = INITIAL FURNISHINGS COST
        7   X   680.   =   4760.

    INITIAL FURRNISHINGS COST / EXPECTED SYSTEM LIFE = ANNUAL FURNISHINGS COST
          4760.   /   20   =   238.

MATERIALS AND SUPPLIES

    TOTAL PERSONS X COST/PERSON = MATERIALS & SUPPLIES COST
        7   X   700.   =   4900.

COMPUTERS/TERMINALS

    NO. DIRECT SUPPORT PEOPLE X INITIAL COST/PERSON = INITIAL COMP TERM COST
           5   X   20000.   =   100000.

    INITIAL COMP TERM COST / EXPECTED SYSTEM LIFE = ANNUAL COMP TERM COST
       100000.   /   20   =   5000.

HARDWARE MAINTENANCE

    HARDWARE COST (1981S) X MAINTENANCE RATIO = ANNUAL HARDWARE MAINTENANCE COS
       660000.   X   0.10   =   66000.

GENERAL SUPPORT EQUIPMENT COST

    FACILITY COST   11118.
    UTILITY COST   1962.
    FURNISHINGS COST   238.
    MATERIALS & SUPPLIES COST   4900.
    COMPUTERS/TERMINALS COST   5000.
 + HARDWARE MAINTENANCE COST   66000.

    GENERAL SUPPORT EQUIPMENT COST   99218.

APPENDIX H

E - 3A

(CE) Command and Control

Historical System

APPENDIX H

E - 3A

(CE) COMMAND AND CONTROL

BREAK DOWN OF ANNUAL COSTS (1981S)
HISTOPICAL SYSTEM
YEAP 1981

TOTAL ANNUAL COST   2190000.

TOTAL LABOR			678244.
DIRECT LABOR		528129.	
REQUIREMENTS REVIEW	25433.		
DESIGN	80321.		
DEVELOPMENT	184587.		
INTEGRATION	26489.		
TEST AND EVALUATION	34349.		
DOCUMENTATION	18633.		
REPRODUCTION/INSTALL	10255.		
SUPPORT SOFTWARE	147861.		
INDIRECT LABOR		150116.	
SUPERVISION	105661.		
ADMINISTRATION	44455.		
TOTAL SUPPORT EQUIPMENT			1511756.
DIRECT		1012504.	
HARDWARE	275000.		
SUPPORT SOFTWARE	357867.		
TEST AIRCRAFT TIME	362880.		
REPRODUCTION	16757.		
GENERAL		499252.	
FACILITY	44608.		
UTILITIES	5904.		
FURNISHINGS	907.		
MATERIALS & SUPPLIES	14000.		
COMPUTERS/TERMINALS	21333.		
HARDWARE MAINTENANCE	412500.		

APPENDIX H

E - 3A

(CE) COMMAND AND CONTROL

DERIVATION OF DIRECT LABOR COSTS BY GRADE
HISTORICAL SYSTEM
YEAR 1981

PHASE	GRADE	NUMBER OF MANMONTHS	COST PER MANMONTH	COST PER GRADE	DIRECT LABOR COST
1. REQUIREMENTS REVEIW					25433.
	GS-12	3.43	3576.	12261.	
	O-3	1.71	3168.	5431.	
	O-4	1.71	4516.	7742.	
2. DESIGN					80321.
	GS-12	12.00	3576.	42912.	
	O-1	5.14	1994.	10255.	
	O-3	8.57	3168.	27154.	
3. DEVELOPMENT					184587.
	GS-11	3.43	2969.	10179.	
	GS-12	20.57	3576.	73563.	
	O-1	25.71	1994.	51274.	
	O-2	6.86	2477.	16985.	
	O-3	10.29	3168.	32585.	
4. INTEGRATION					26489.
	O-1	5.14	1994.	10255.	
	O-2	3.43	2477.	8493.	
	O-4	1.71	4516.	7742.	
5. TEST AND EVALUATION					34349.
	GS-11	1.71	2969.	5090.	
	GS-12	1.71	3576.	6130.	
	O-1	3.43	1994.	6837.	
	O-3	5.14	3168.	16293.	
6. DOCUMENTATION					18833.
	GS-9	3.43	2502.	8578.	
	O-1	5.14	1994.	10255.	
7. REPRO/INSTALLATION					10255.
	O-1	5.14	1994.	10255.	
9. SUPPORT SOFTWARE					147861.
	GS-12	25.71	3576.	91954.	
	O-1	17.14	1994.	34183.	
	O-3	6.86	3168.	21723.	
TOTAL		185.14	3005.	528129.	528129.

NOTE: ACTUAL BLOCK CHANGE LENGTH IS 7 MONTHS

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APPENDIX B

E - 3A

(CE) COMMAND AND CONTROL

DERIVATION OF ANNUAL INDIRECT LABOR COSTS (1981$)
HISTORICAL SYSTEM
YEAR 1981

SUPERVISION

DIRECT ANNUALIZED ON-SITE MANMONTHS X SUPERVISN RATIO = SUPERVISN MANMONTHS
           185.14   X   0.13   =   24.07

SUPERVISION MANMONTHS X COST/MANMONTH = SUPERVISION COST
    24.07   X   4390.   =   105661.

ADMINISTRATIVE

DIRECT ANNUALIZED ON-SITE MANMONTHS X ADMNSTIVE RATIO = ADMNSTIVE MANMONTHS
           185.14   X   0.13   =   24.07

ADMNSTIVE MANMONTHS X COST/MANMONTH X ADM COMP-FACT = ADMNSTIVE COST
    24.07   X   1847.   X   1.000   =   44455.

TOTAL INDIRECT LABOR

SUPERVISION + ADMINISTRATIVE = INDIRECT LABOR COSTS
   105661. +   44455.   =   150116.

APPENDIX H

E - 3A

(CE) COMMAND AND CONTROL

DERIVATION OF ANNUAL DIRECT SUPPORT EQUIPMENT COSTS (1981$)
HISTORICAL SYSTEM
YEAR 1981

EQUIPMENT

	HARDWARE	SUPPORT SOFTWARE	TOTAL
INITIAL COST (1981$)	4125000.	5368000.	9493000.
COST (1981$)	4125000.	5368000.	9493000.
EXPECTED SYSTEM LIFE	15	15	15
ANNUAL EQUIPMENT COST	275000.	357867.	632867.

TEST AIRCRAFT/TIME

ANNUAL T&E MANMONTHS X 144 = ANNUAL T&E MANHOURS
2.36   X 144 =   1728.00

ANNUAL T&E MANHOURS X T&E RATIO = TEST AIRCRAFT HOURS
1728.00   X   0.035   =   60.48

TEST AIRCRAFT HOURS X COST/HOUR = ANNUAL AIRCRAFT/TIME COST
60.48   X   6000. =   362880.

REPRODUCTION

NUMBER OF FIELDED SYSTEMS X MED REP-FACT X COST/REPRO = REPRODUCTION COST
23   X   25.000   X   17.00   =   9775.

REPRODUCTION COST X 12 / BLOCK CHANGE LENGTH = ANNUAL REPRODUCTION COST
9775.   X 12 /   7   =   16757.

DIRECT SUPPORT EQUIPMENT COSTS

DIRECT HARDWARE COST	275000.
DIRECT SOFTWARE COST	357867.
AIRCRAFT/TIME COST	362880.
+ REPRODUCTION COST	16757.
DIRECT SUPPORT EQUIPMENT COST	1012504.

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APPENDIX H

E - 3A

(CE) COMMAND AND CONTROL

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981S)
HISTORICAL SYSTEM
YEAR 1981

PEOPLE REQUIRED

REQUIRED ANNUAL ON-SITE MANMONTHS / 12 = NO. OF DIRECT SUPPORT PEOPLE
        185.14   / 12 =   16

ANNUAL SUPERVISION MANMONTHS / 12 = NO. OF SUPERVISORS
        24.07   / 12 =   2

ANNUAL ADMINISTRATIVE MANMONTHS / 12 = NO. OF ADMINISTRTRS
        24.07   / 12 =   2

NO. OF DIRECT SUPPORT PEOPLE   16
NO. OF SUPERVISORS   2
+ NO. OF ADMINISTRATORS   2

NO. OF PEOPLE   20

FACILITY

DIRECT SUPPORT PEOPLE X REQ. TECHNICAL SPACE/PERSON = REQ. WORKING SPACE
        16   X   275.   =   4400.00

(SUPERVSRS + ADMNSTRTRS) X REQ. SUPERVISORY SPACE/PERSON = ADDITIONAL SPACE
(2   +   2   ) X   130.   =   520.00

REQUIRED WORKING SPACE + ADDITIONAL SPACE = TOTAL SPACE
        4400.00   +   520.00   =   4920.00

TOTAL SPACE X COST/SQUARE FOOT = FACILITY COST
    4920.00   X   136.00   =   669120.

FACILITY COST / EXPECTED SYSTEM LIFE = ANNUAL FACILITY COST
    669120.   /   15   =   44608.

UTILITIES

TOTAL SPACE X COST/SQUARE FOOT = UTILITY COST
    4920.00   X   1.20   =   5904.

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APPENDIX H

E - 3A

(CE) COMMAND AND CONTROL

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981s)
HISTORICAL SYSTEM
YEAR 1981

FURNISHINGS

    TOTAL PERSONS X INITIAL COST/PERSON = INITIAL FURNISHINGS COST
        20   X   680.   =   13600.

    INITIAL FURNISHINGS COST / EXPECTED SYSTEM LIFE = ANNUAL FURNISHINGS COST
            13600.   /   15   =   907.

MATERIALS AND SUPPLIES

    TOTAL PERSONS X COST/PERSON = MATERIALS & SUPPLIES COST
        20   X   700.   =   14000.

COMPUTERS/TERMINALS

    NO. DIRECT SUPPORT PEOPLE X INITIAL COST/PERSON = INITIAL COMP TERM COST
            16   X   20000.   =   320000.

    INITIAL COMP TERM COST / EXPECTED SYSTEM LIFE = ANNUAL COMP TERM COST
            320000.   /   15   =   21333.

HARDWARE MAINTENANCE

    HARDWARE COST (1981s) X MAINTENANCE RATIO = ANNUAL HARDWARE MAINTENANCE COST
            4125000.   X   0.10   =   412500.

GENERAL SUPPORT EQUIPMENT COST

        FACILITY COST   44608.
        UTILITY COST   5904.
        FURNISHINGS COST   907.
        MATERIALS & SUPPLIES COST   14000.
        COMPUTERS/TERMINALS COST   21333.
      + HARDWARE MAINTENANCE COST   412500.
        ----------------------------- ------------
        GENERAL SUPPORT EQUIPMENT COST   499252.

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APPENDIX
I

APPENDIX I

COMPUTATION OF COSTS OTHER THAN
DIRECT LABOR

1. COMPUTATION OF ANNUAL INDIRECT LABOR COSTS

SUPERVISION

ANNUAL DIRECT ON-SITE MANMONTHS X SUPERVISION RATIO = SUPERVISION MANMONTHS

SUPERVISION MANMONTHS X COST/MANMONTH = ANNUAL SUPERVISION COST

ADMINISTRATION

ANNUAL DIRECT ON-SITE MANMONTHS X ADMINISTRATIVE RATIO = ADMIN MANMONTHS

ADMIN MANMONTHS X COST/MANMONTH X COMPLEXITY FACTOR = ADMIN COST

TOTAL INDIRECT (FIRST LEVEL) LABOR COSTS

SUPERVISION + ADMINISTRATIVE = ANNUAL INDIRECT LABOR COST

2. COMPUTATION OF ANNUAL DIRECT SUPPORT EQUIPMENT COSTS

TEST AIRCRAFT/TIME

ANNUAL T&E MANMONTHS X 144 = ANNUAL T&E MANHOURS

ANNUAL T&E MANHOURS X T&E RATIO = TEST AIRCRAFT HOURS

TEST AIRCRAFT HOURS X COST/HOUR = ANNUAL TEST AIRCRAFT/TIME COST

REPRODUCTION

NUMBER OF FIELDED SYSTEMS X MEDIUM FACTOR X COST/REPRODUCTION = REPRO COST

REPRODUCTION COST X 12 ÷ LENGTH OF BLOCK CHANGE = ANNUAL REPRODUCTION COST

APPENDIX I

3. COMPUTATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS

PEOPLE REQUIRED

REQUIRED ON-SITE MANMONTHS ÷ 12.6 = NO. OF DIRECT SUPPORT PEOPLE

SUPERVISION MANMONTHS ÷ 12.6 = NO. OF SUPERVISORS

ADMINISTRATIVE MANMONTHS ÷ 12.6 = NO. OF ADMINISTRATORS

NO. DIRECT SUPPORT PEOPLE + SUPERVISORS + ADMINISTRATORS = NO. OF PEOPLE

FACILITY

NO. DIRECT SUPPORT PEOPLE X REQ TECHNICAL SPACE/PERSON = REQ WORKING SPACE

(NO. OF SUPERVISORS + ADMINISTRATORS) X REQ SUP SPACE/PERSON = ADD'L SPACE

REQUIRED WORKING SPACE + ADDITIONAL SPACE = TOTAL SPACE

TOTAL SPACE X COST/SQUARE FOOT = FACILITY COST

FACILITY COST ÷ EXPECTED SYSTEM LIFE = ANNUAL FACILITY COST

UTILITIES

TOTAL SPACE X COST/SQUARE FOOT = ANNUAL UTILITY COST

FURNISHINGS

NUMBER OF PEOPLE X INITIAL COST/PERSON = INITIAL FURNISHINGS COST

INITIAL FURNISHINGS COST ÷ EXPECTED SYSTEM LIFE = ANNUAL FURNISHINGS COST

MATERIALS/SUPPIES

NUMBER OF PEOPLE X COST/PERSON = ANNUAL MATERIALS/SUPPLIES COST

COMPUTER/TERMINALS

NO DIRECT SUPPORT PEOPLE X INIT COST/PERSON = INIT COMPUTER/TERMINALS COST

INITIAL COMPUTER/TERMINALS COST ÷ EXPECTED SYSTEM LIFE = ANNUAL C/T COST

HARDWARE MAINTENANCE

HARDWARE COST X MAINTENANCE RATIO = ANNUAL HARDWARE MAINTENANCE COST

APPENDIX
J

APPENDIX J

(OFP) Navigational Weapon Delivery

Representative System

APPENDIX J

(OFP) NAVIGATION WEAPON DELIVERY

BREAK DOWN OF ANNUAL COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1981

TOTAL ANNUAL COST   1018461.

TOTAL LABOR			353839.
DIRECT LABOR		284470.	
REQUIREMENTS REVIEW	20015.		
DESIGN	26460.		
DEVELOPMENT	26679.		
INTEGRATION	43836.		
TEST AND EVALUATION	53455.		
DOCUMENTATION	30382.		
REPRODUCTION/INSTALL	25144.		
SUPPORT SOFTWARE	58500.		
INDIRECT LABOR		69369.	
SUPERVISION	48826.		
ADMINISTRATION	20543.		
TOTAL SUPPORT EQUIPMENT			664622.
DIRECT		355902.	
HARDWARE	136850.		
SUPPORT SOFTWARE	63150.		
TEST AIRCRAFT TIME	138902.		
REPRODUCTION	17000.		
GENERAL		308720.	
FACILITY	16728.		
UTILITIES	2952.		
FURNISHINGS	340.		
MATERIALS & SUPPLIES	7000.		
COMPUTERS/TERMINALS	8000.		
HARDWARE MAINTENANCE	273700.		

APPENDIX J

(OFP) NAVIGATION WEAPON DELIVERY

DERIVATION OF ANNUAL DIRECT LABOR COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1981

PHASE	REQUIRED MANMONTHS	COST PER MANMONTH	DIRECT LABOR COST
1. REQUIREMENTS REVEIW	6.02	3325.	20015.
2. DESIGN	7.96	3325.	26460.
3. DEVELOPMENT	8.02	3325.	26679.
4. INTEGRATION	13.18	3325.	43836.
5. TEST AND EVALUATION	16.08	3325.	53455.
6. DOCUMENTATION	9.14	3325.	30382.
7. REPRO/INSTALLATION	7.56	3325.	25144.
8. SUPPORT SOFTWARE	17.59	3325.	58500.
TOTAL	85.55	3325.	284470.

APPENDIX J

(OFP) NAVIGATION WEAPON DELIVERY

DERIVATION OF ANNUAL INDIRECT LABOR COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1981

SUPERVISION

DIRECT ANNUALIZED ON-SITE MANMONTHS X SUPERVISN RATIO = SUPERVISN MANMONT
85.55   X   0.13   =   11.12

SUPERVISION MANMONTHS X COST/MANMONTH = SUPERVISION COST
11.12   X   4390.   =   48826.

ADMINISTRATIVE

DIRECT ANNUALIZED ON-SITE MANMONTHS X ADMNSTIVE RATIO = ADMNSTIVE MANMONT
85.55   X   0.13   =   11.12

ADMNSTIVE MANMONTHS X COST/MANMONTH X ADM COMP-FACT = ADMNSTIVE COST
11.12   X   1847.   X   1.000   =   20543.

TOTAL INDIRECT LABOR

SUPERVISION + ADMINISTRATIVE = INDIRECT LABOR COSTS
48826.   +   20543.   =   69369.

APPENDIX J

(UFP) NAVIGATION WEAPON DELIVERY

DERIVATION OF ANNUAL DIRECT SUPPORT EQUIPMENT COSTS (1981$)
REPRESENTATIVE SYSTEM
YEAR 1981

EQUIPMENT

	HARDWARE	SUPPORT SOFTWARE	TOTAL
INITIAL COST (1981$)	2737000.	1263000.	4000000.
COST (1981$)	2737000.	1263000.	4000000.
EXPECTED SYSTEM LIFE	20	20	20
ANNUAL EQUIPMENT COST	136850.	63150.	200000.

TEST AIRCRAFT/TIME

ANNUAL T&E MANMONTHS X 144 = ANNUAL T&E MANHOURS
    16.08   X 144 =   2315.03

ANNUAL T&E MANHOURS X T&E RATIO = TEST AIRCRAFT HOURS
    2315.03   X 0.030   =   69.45

TEST AIRCRAFT HOURS X COST/HOUR = ANNUAL AIRCRAFT/TIME COST
    69.45   X   2000.   =   138902.

REPRODUCTION

NUMBER OF FIELDED SYSTEMS X MED REP-FACT X COST/REPRO = REPRODUCTION COST
    500   X   2.000   X 17.00   =   17000.

REPRODUCTION COST X 12 / BLOCK CHANGE LENGTH = ANNUAL REPRODUCTION COST
    17000.   X 12 /   12   =   17000.

DIRECT SUPPORT EQUIPMENT COSTS

DIRECT HARDWARE COST	136850.
DIRECT SOFTWARE COST	63150.
AIRCRAFT/TIME COST	138902.
+ REPRODUCTION COST	17000.
DIRECT SUPPORT EQUIPMENT COST	355902.

APPENDIX J

(OFP) NAVIGATION WEAPON DELIVERY

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981$)
REPRESENTATIVE SYSTEM
YEAR 1981

PEOPLE REQUIRED

REQUIRED ANNUAL ON-SITE MANMONTHS / 12 = NO. OF DIRECT SUPPORT PEOPLE
        85.55   / 12 =   8

ANNUAL SUPERVISION MANMONTHS / 12 = NO. OF SUPERVISORS
        11.12   / 12 =   1

ANNUAL ADMINISTRATIVE MANMONTHS / 12 = NO. OF ADMINISTRTRS
        11.12   / 12 =   1

  NO. OF DIRECT SUPPORT PEOPLE   8
  NO. OF SUPERVISORS   1
+ NO. OF ADMINISTRATORS   1
------------------------------------- ----
  NO. OF PEOPLE   10

FACILITY

DIRECT SUPPORT PEOPLE X REQ. TECHNICAL SPACE/PERSON = REQ. WORKING SPACE
        8   X   275.   =   2200.00

(SUPERVSRS + ADMNSTRTRS) X REQ. SUPERVISORY SPACE/PERSON = ADDITIONAL SPACE
(1   +   1   ) X   130.   =   260.00

REQUIRED WORKING SPACE + ADDITIONAL SPACE = TOTAL SPACE
     2200.00   +   260.00   = 2460.00

TOTAL SPACE X COST/SQUARE FOOT = FACILITY COST
  2460.00   X   136.00   =   334560.

FACILITY COST / EXPECTED SYSTEM LIFE = ANNUAL FACILITY COST
    334560. /   20   =   16728.

UTILITIES

TOTAL SPACE X COST/SQUARE FOOT = UTILITY COST
  2460.00   X   1.20   =   2952.

APPENDIX J

(OFP) NAVIGATION WEAPON DELIVERY

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981s)
REPRESENTATIVE SYSTEM
YEAR 1981

FURNISHINGS

TOTAL PERSONS X INITIAL COST/PERSON = INITIAL FURNISHINGS COST
10   X   680.   =   6800.

INITIAL FURNISHINGS COST / EXPECTED SYSTEM LIFE = ANNUAL FURNISHINGS COST
6800.   /   20   =   340.

MATERIALS AND SUPPLIES

TOTAL PERSONS X COST/PERSON = MATERIALS & SUPPLIES COST
10   X   700.   =   7000.

COMPUTERS/TERMINALS

NO. DIRECT SUPPORT PEOPLE X INITIAL COST/PERSON = INITIAL COMP TERM COST
8   X   20000.   =   160000.

INITIAL COMP TERM COST / EXPECTED SYSTEM LIFE = ANNUAL COMP TERM COST
160000.   /   20   =   8000.

HARDWARE MAINTENANCE

HARDWARE COST (1981S) X MAINTENANCE RATIO = ANNUAL HARDWARE MAINTENANCE COST
2737000.   X   0.10   =   273700.

GENERAL SUPPORT EQUIPMENT COST

FACILITY COST   16728.
UTILITY COST   2952.
FURNISHINGS COST   340.
MATERIALS & SUPPLIES COST   7000.
COMPUTERS/TERMINALS COST   8000.
+ HARDWARE MAINTENANCE COST   273700.

GENERAL SUPPORT EQUIPMENT COST   308720.

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APPENDIX J

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Representative System

APPENDIX J

(EW) JAMMER

BREAK DOWN OF ANNUAL COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1981

TOTAL ANNUAL COST   733302.

TOTAL LABOR   126816.
    DIRECT LABOR   101954.
        REQUIREMENTS REVIEW   7817.
        DESIGN   9329.
        DEVELOPMENT   8823.
        INTEGRATION   9398.
        TEST AND EVALUATION   25980.
        DOCUMENTATION   26037.
        REPRODUCTION/INSTALL   8508.
        SUPPORT SOFTWARE   6062.
    INDIRECT LABOR   24862.
        SUPERVISION   17499.
        ADMINISTRATION   7362.

TOTAL SUPPORT EQUIPMENT   606486.
    DIRECT   465035.
        HARDWARE   63050.
        SUPPORT SOFTWARE   286950.
        TEST AIRCRAFT TIME   112515.
        REPRODUCTION   2520.
    GENERAL   141450.
        FACILITY   7378.
        UTILITIES   1302.
        FURNISHINGS   170.
        MATERIALS & SUPPLIES   3500.
        COMPUTERS/TERMINALS   3000.
        HARDWARE MAINTENANCE   126100.

APPENDIX J

(EW) JAMMFR

DERIVATION OF ANNUAL DIRECT LABOR COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1991

PHASE	REQUIRED MANMONTHS	COST PER MANMONTH	DIRECT LABOR COST
1. REQUIREMENTS REVEIW	2.35	3325.	7817.
2. DESIGN	2.81	3325.	9329.
3. DEVELOPMENT	2.65	3325.	8823.
4. INTEGRATION	2.83	3325.	9398.
5. TEST AND EVALUATION	7.81	3325.	25980.
6. DOCUMENTATION	7.83	3325.	26037.
7. PEPRO/INSTALLATION	2.56	3325.	850R.
8. SUPPORT SOFTWARE	1.82	3325.	6062.
TOTAL	30.66	3325.	101954.

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APPENDIX J

(EW) JAMMER

DERIVATION OF ANNUAL INDIRECT LABOR COSTS (1981$)
REPRESENTATIVE SYSTEM
YEAR 1981

SUPERVISION

    DIRECT ANNUALIZED ON-SITE MANMONTHS X SUPERVISN RATIO = SUPERVISN MANMONTHS
                30.66   X   0.13   =   3.99

    SUPERVISION MANMONTHS X COST/MANMONTH = SUPERVISION COST
            3.99   X   4390.   =   17499.

ADMINISTRATIVE

    DIRECT ANNUALIZED ON-SITE MANMONTHS X ADMNSTIVE RATIO = ADMNSTIVE MANMONTHS
                30.66   X   0.13   =   3.99

    ADMNSTIVE MANMONTHS X COST/MANMONTH X ADM COMP-FACT = ADMNSTIVE COST
            3.99   X   1847.   X   1.000   =   7362.

TOTAL INDIRECT LABOR

    SUPERVISION + ADMINISTRATIVE = INDIRECT LABOR COSTS
        17499.   +   7362.   =   24862.

APPENDIX J

(FW) JAMMER

DERIVATION OF ANNUAL DIRECT SUPPORT EQUIPMENT COSTS (1981$)
REPRESENTATIVE SYSTEM
YEAR 1981

EQUIPMENT

	HARDWARE	SUPPORT SOFTWARE	TOTAL
INITIAL COST (1981$)	1261000.	5739000.	7000000.
COST (1981$)	1261000.	5739000.	7000000.
EXPECTED SYSTEM LIFE	20	20	20
ANNUAL EQUIPMENT COST	63050.	286950.	350000.

TEST AIRCRAFT/TIME

ANNUAL T&E MANMONTHS X 144 = ANNUAL T&E MANHOURS
   7.81   X 144 =   1125.15

ANNUAL T&E MANHOURS X T&E RATIO = TEST AIRCRAFT HOURS
   1125.15   X 0.050   =   56.26

TEST AIRCRAFT HOURS X COST/HOUR = ANNUAL AIRCRAFT/TIME COST
   56.26   X   2000. =   112515.

REPRODUCTION

NUMBER OF FIELDED SYSTEMS X MED REP-FACT X COST/REPRO = REPRODUCTION COST
   600   X   0.120   X   35.00   =   2520.

REPRODUCTION COST X 12 / BLOCK CHANGE LENGTH = ANNUAL REPRODUCTION COST
   2520.   X 12 /   12   =   2520.

DIRECT SUPPORT EQUIPMENT COSTS

DIRECT HARDWARE COST	63050.
DIRECT SOFTWARE COST	286950.
AIRCRAFT/TIME COST	112515.
+ REPRODUCTION COST	2520.
DIRECT SUPPORT EQUIPMENT COST	465035.

APPENDIX J

(EW) JAMMER

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981s)
REPRESENTATIVE SYSTEM
YEAR 1981

PEOPLE REQUIRED

REQUIRED ANNUAL ON-SITE MANMONTHS / 12 = NO. OF DIRECT SUPPORT PEOPLE
            30.66   / 12 =   3

ANNUAL SUPERVISION MANMONTHS / 12 = NO. OF SUPERVISORS
            3.99   / 12 =   1

ANNUAL ADMINISTRATIVE MANMONTHS / 12 = NO. OF ADMINISTRTRS
            3.99   / 12 =   1

    NO. OF DIRECT SUPPORT PEOPLE   3
    NO. OF SUPERVISORS   1
  + NO. OF ADMINISTRATORS   1
    ----------------------------------- ----
    NO. OF PEOPLE   5

FACILITY

    DIRECT SUPPORT PEOPLE X REQ. TECHNICAL SPACE/PERSON = REQ. WORKING SPACE
            3   X   275.   =   825.00

    (SUPERVSRS + ADMNSTRTRS) X REQ. SUPERVISORY SPACE/PERSON = ADDITIONAL SPACE
    (1   +   1   ) X   130.   =   260.00

    REQUIRED WORKING SPACE + ADDITIONAL SPACE = TOTAL SPACE
            825.00   +   260.00   =   1085.00

    TOTAL SPACE X COST/SQUARE FOOT = FACILITY COST
        1085.00   X   136.00   =   147560.

    FACILITY COST / EXPECTED SYSTEM LIFE = ANNUAL FACILITY COST
        147560.   /   20   =   7378.

UTILITIES

    TOTAL SPACE X COST/SQUARE FOOT = UTILITY COST
        1085.00   X   1.20   =   1302.

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APPENDIX J

APPENDIX J

(EW) JAMMER

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981$)
REPRESENTATIVE SYSTEM
YEAR 1981

FURNISHINGS

    TOTAL PERSONS X INITIAL COST/PERSON = INITIAL FURNISHINGS COST
         5   X   680.   =   3400.

    INITIAL FURNISHINGS COST / EXPECTED SYSTEM LIFE = ANNUAL FURNISHINGS COST
              3400.   /   20   =   170.

MATERIALS AND SUPPLIES

    TOTAL PERSONS X COST/PERSON = MATERIALS & SUPPLIES COST
         5   X   700.   =   3500.

COMPUTERS/TERMINALS

    NO. DIRECT SUPPORT PEOPLE X INITIAL COST/PERSON = INITIAL COMP TERM COST
              3   X   20000.   =   60000.

    INITIAL COMP TERM COST / EXPECTED SYSTEM LIFE = ANNUAL COMP TERM COST
              60000.   /   20   =   3000.

HARDWARE MAINTENANCE

    HARDWARE COST (1981$) X MAINTENANCE RATIO = ANNUAL HARDWARE MAINTENANCE CO
            1261000.   X   0.10   =   126100.

GENERAL SUPPORT EQUIPMENT COST

        FACILITY COST   7378.
        UTILITY COST   1302.
        FURNISHINGS COST   170.
        MATERIALS & SUPPLIES COST   3500.
        COMPUTERS/TERMINALS COST   3000.
      + HARDWARE MAINTENANCE COST   126100.
        ----------------------------- -----------
        GENERAL SUPPORT EQUIPMENT COST 141450.

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APPENDIX J

(OFP) Fire Control

Representative System

APPENDIX J

(OFP) FIRE CONTROL

BREAK DOWN OF ANNUAL COSTS (1981s)
REPRESENTATIVE SYSTEM
YEAR 1981

TOTAL ANNUAL COST   1361742.

TOTAL LABOR			655338.
DIRECT LABOR		535900.	
REQUIREMENTS REVIEW	79262.		
DESIGN	91270.		
DEVELOPMENT	89296.		
INTEGRATION	39373.		
TEST AND EVALUATION	66388.		
DOCUMENTATION	44637.		
REPRODUCTION/INSTALL	3013.		
SUPPORT SOFTWARE	122662.		
INDIRECT LABOR		119437.	
SUPERVISION	84068.		
ADMINISTRATION	35370.		
TOTAL SUPPORT EQUIPMENT			706404.
DIRECT		381466.	
HARDWARE	133350.		
SUPPORT SOFTWARE	66650.		
TEST AIRCRAFT TIME	157666.		
REPRODUCTION	23800.		
GENERAL		324938.	
FACILITY	27846.		
UTILITIES	4914.		
FURNISHINGS	578.		
MATERIALS & SUPPLIES	11900.		
COMPUTERS/TERMINALS	13000.		
HARDWARE MAINTENANCE	266700.		

APPENDIX J

(OFP) FIRE CONTROL

DERIVATION OF ANNUAL DIRECT LABOR COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1981

PHASE	REQUIRED MANMONTHS	COST PER MANMONTH	DIRECT LABOR COST
1. REQUIREMENTS REVEIW	21.79	3638.	79262.
2. DESIGN	25.09	3638.	91270.
3. DEVELOPMENT	24.55	3638.	89296.
4. INTEGRATION	10.82	3638.	39373.
5. TEST AND EVALUATION	18.25	3638.	66388.
6. DOCUMENTATION	12.27	3638.	44637.
7. REPRO/INSTALLATION	0.83	3638.	3013.
8. SUPPORT SOFTWARE	33.72	3638.	122662.
TOTAL	147.31	3638.	535900.

APPENDIX J

(OFP) FIRE CONTROL

DERIVATION OF ANNUAL INDIRECT LABOR COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1981

SUPERVISION

DIRECT ANNUALIZED ON-SITE MANMONTHS X SUPERVISN RATIO = SUPERVISN MANMONTHS
                147.31   X   0.13   =   19.15

SUPERVISION MANMONTHS X COST/MANMONTH = SUPERVISION COST
        19.15   X   4390.   =   84068.

ADMINISTRATIVE

DIRECT ANNUALIZED ON-SITE MANMONTHS X ADMNSTIVE RATIO = ADMNSTIVE MANMONTHS
                147.31   X   0.13   =   19.15

ADMNSTIVE MANMONTHS X COST/MANMONTH X ADM COMP-FACT = ADMNSTIVE COST
        19.15   X   1847.   X   1.000   =   35370.

TOTAL INDIRECT LABOR

SUPERVISION + ADMINISTRATIVE = INDIRECT LABOR COSTS
   84068.   +   35370.   =   119437.

APPENDIX J

(OFP) FIRE CONTROL

DERIVATION OF ANNUAL DIRECT SUPPORT EQUIPMENT COSTS (1981$)
REPRESENTATIVE SYSTEM
YEAR 1981

EQUIPMENT

	HARDWARE	SUPPORT SOFTWARE	TOTAL
INITIAL COST (1981$)	2667000.	1333000.	4000000.
COST (1981$)	2667000.	1333000.	4000000.
EXPECTED SYSTEM LIFE	20	20	20
ANNUAL EQUIPMENT COST	133350.	66650.	200000.

TEST AIRCRAFT/TIME

ANNUAL T&E MANMONTHS X 144 = ANNUAL T&E MANHOURS
    18.25   X 144 =   2627.77

ANNUAL T&E MANHOURS X T&E RATIO = TEST AIRCRAFT HOURS
    2627.77   X   0.030   =   78.83

TEST AIRCRAFT HOURS X COST/HOUR = ANNUAL AIRCRAFT/TIME COST
    78.83   X   2000.   =   157666.

REPRODUCTION

NUMBER OF FIELDED SYSTEMS X MED REP-FACT X COST/REPRO = REPRODUCTION COST
    700   X   2.000   X   17.00   =   23800.

REPRODUCTION COST X 12 / BLOCK CHANGE LENGTH = ANNUAL REPRODUCTION COST
    23800.   X 12 /   12   =   23800.

DIRECT SUPPORT EQUIPMENT COSTS

DIRECT HARDWARE COST	133350.
DIRECT SOFTWARE COST	66650.
AIRCRAFT/TIME COST	157666.
+ REPRODUCTION COST	23800.
DIRECT SUPPORT EQUIPMENT COST	381466.

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APPENDIX J

(OFP) FIRE CONTROL

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1981

PEOPLE REQUIRED

REQUIRED ANNUAL ON-SITE MANMONTHS / 12 = NO. OF DIRECT SUPPORT PEOPLE
                   147.31   / 12 =   13

ANNUAL SUPERVISION MANMONTHS / 12 = NO. OF SUPERVISORS
              19.15   / 12 =   2

ANNUAL ADMINISTRATIVE MANMONTHS / 12 = NO. OF ADMINISTRTRS
              19.15   / 12 =   2

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   NO. OF DIRECT SUPPORT PEOPLE    13
   NO. OF SUPERVISORS               2
 + NO. OF ADMINISTRATORS            2
   -----------------------------  ----
   NO. OF PEOPLE                   17
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FACILITY

DIRECT SUPPORT PEOPLE X REQ. TECHNICAL SPACE/PERSON = REQ. WORKING SPACE
            13   X   275.   =   3575.00

(SUPERVSRS + ADMNSTRTRS) X REQ. SUPERVISORY SPACE/PERSON = ADDITIONAL SPACE
(2   +   2   ) X   130.   =   520.00

REQUIRED WORKING SPACE + ADDITIONAL SPACE = TOTAL SPACE
         3575.00   +   520.00   =   4095.00

TOTAL SPACE X COST/SQUARE FOOT = FACILITY COST
   4095.00   X   136.00   =   556920.

FACILITY COST / EXPECTED SYSTEM LIFE = ANNUAL FACILITY COST
      556920. /   20   =   27846.

UTILITIES

TOTAL SPACE X COST/SQUARE FOOT = UTILITY COST
   4095.00   X   1.20   =   4914.

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APPENDIX J

(OFP) FIRE CONTROL

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981s)
REPRESENTATIVE SYSTEM
YEAR 1981

FURNISHINGS

TOTAL PERSONS X INITIAL COST/PERSON = INITIAL FURNISHINGS COST
    17   X   680.   =   11560.

INITIAL FURNISHINGS COST / EXPECTED SYSTEM LIFE = ANNUAL FURNISHINGS COST
       11560.   /   20   =   578.

MATERIALS AND SUPPLIES

TOTAL PERSONS X COST/PERSON = MATERIALS & SUPPLIES COST
    17   X   700.   =   11900.

COMPUTERS/TERMINALS

NO. DIRECT SUPPORT PEOPLE X INITIAL COST/PERSON = INITIAL COMP TERM COST
       13   X   20000.   =   260000.

INITIAL COMP TERM COST / EXPECTED SYSTEM LIFE = ANNUAL COMP TERM COST
      260000.   /   20   =   13000.

HARDWARE MAINTENANCE

HARDWARE COST (1981s) X MAINTENANCE RATIO = ANNUAL HARDWARE MAINTENANCE COS
    2667000.   X   0.10   =   266700.

GENERAL SUPPORT EQUIPMENT COST

FACILITY COST	27846.
UTILITY COST	4914.
FURNISHINGS COST	578.
MATERIALS & SUPPLIES COST	11900.
COMPUTERS/TERMINALS COST	13000.
+ HARDWARE MAINTENANCE COST	266700.
GENERAL SUPPORT EQUIPMENT COST	324939.

APPENDIX J

(EW) Receiver

Representative System

APPENDIX J

(EW) RECEIVER

BREAK DOWN OF ANNUAL COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1991

TOTAL ANNUAL COST   2500159.

TOTAL LABOR			108279.
DIRECT LABOR		87052.	
REQUIREMENTS REVIEW	4164.		
DESIGN	17480.		
DEVELOPMENT	19684.		
INTEGRATION	11691.		
TEST AND EVALUATION	7349.		
DOCUMENTATION	6552.		
REPRODUCTION/INSTALL	6681.		
SUPPORT SOFTWARE	14450.		
INDIRECT LABOR		21228.	
SUPERVISION	14941.		
ADMINISTRATION	6286.		
TOTAL SUPPORT EQUIPMENT			2391880.
DIRECT		1819429.	
HARDWARE	278550.		
SUPPORT SOFTWARE	171450.		
TEST AIRCRAFT TIME	31829.		
REPRODUCTION	1337600.		
GENERAL		572450.	
FACILITY	7378.		
UTILITIES	1302.		
FURNISHINGS	170.		
MATERIALS & SUPPLIES	3500.		
COMPUTERS/TERMINALS	3000.		
HARDWARE MAINTENANCE	557100.		

APPENDIX J

(EW) RECEIVER

DERIVATION OF ANNUAL DIRECT LABOR COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1981

PHASE	REQUIRED MANMONTHS	COST PER MANMONTH	DIRECT LABOR COST
1. REQUIREMENTS REVEIW	1.25	3325.	4164.
2. DESIGN	5.26	3325.	17480.
3. DEVELOPMENT	5.62	3325.	18684.
4. INTEGRATION	3.52	3325.	11691.
5. TEST AND EVALUATION	2.21	3325.	7349.
6. DOCUMENTATION	1.97	3325.	6552.
7. PEPRO/INSTALLATION	2.01	3325.	6681.
8. SUPPORT SOFTWARE	4.35	3325.	14450.
TOTAL	26.18	3325.	87052.

APPENDIX J

(EW) RECEIVER

DERIVATION OF ANNUAL INDIRECT LABOR COSTS (1981$)
REPRESENTATIVE SYSTEM
YEAR 1981

SUPERVISION

DIRECT ANNUALIZED ON-SITE MANMONTHS X SUPERVISN RATIO = SUPERVISN MANMONTHS
             26.18   X   0.13   =   3.40

SUPERVISION MANMONTHS X COST/MANMONTH = SUPERVISION COST
      3.40   X   4390.   =   14941.

ADMINISTRATIVE

DIRECT ANNUALIZED ON-SITE MANMONTHS X ADMNSTIVE RATIO = ADMNSTIVE MANMONTHS
             26.18   X   0.13   =   3.40

ADMNSTIVE MANMONTHS X COST/MANMONTH X ADM COMP-FACT = ADMNSTIVE COST
      3.40   X   1847.   X   1.000   =   6286.

TOTAL INDIRECT LABOR

SUPERVISION + ADMINISTRATIVE = INDIRECT LABOR COSTS
  14941. +   6286.   =   21228.

APPENDIX J

(EW) RECEIVER

DERIVATION OF ANNUAL DIRECT SUPPORT EQUIPMENT COSTS (1981$)
REPRESENTATIVE SYSTEM
YEAR 1981

EQUIPMENT

	HARDWARE	SUPPORT SOFTWARE	TOTAL
INITIAL COST (1981$)	5571000.	3429000.	9000000.
COST (1981$)	5571000.	3429000.	9000000.
EXPECTED SYSTEM LIFE	20	20	20
ANNUAL EQUIPMENT COST	278550.	171450.	450000.

TEST AIRCRAFT/TIME

ANNUAL T&E MANMONTHS X 144 = ANNUAL T&E MANHOURS
      2.21   X 144 =   318.29

ANNUAL T&E MANHOURS X T&E RATIO = TEST AIRCRAFT HOURS
      318.29   X   0.050   =   15.91

TEST AIRCRAFT HOURS X COST/HOUR = ANNUAL AIRCRAFT/TIME COST
      15.91   X   2000.   =   31829.

REPRODUCTION

NUMBER OF FIELDED SYSTEMS X MED REP-FACT X COST/REPRO = REPRODUCTION COST
        950   X   70.400   X   20.00   =   1337600.

REPRODUCTION COST X 12 / BLOCK CHANGE LENGTH = ANNUAL REPRODUCTION COST
    1337600.   X 12 /   12   =   1337600.

DIRECT SUPPORT EQUIPMENT COSTS

DIRECT HARDWARE COST	278550.
DIRECT SOFTWARE COST	171450.
AIRCRAFT/TIME COST	31829.
+ REPRODUCTION COST	1337600.
DIRECT SUPPORT EQUIPMENT COST	1819429.

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APPENDIX J

(Ew) RECEIVER

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981s)
REPRESENTATIVE SYSTEM
YEAR 1981

PEOPLE REQUIRED

    REQUIRED ANNUAL ON-SITE MANMONTHS / 12 = NO. OF DIRECT SUPPORT PEOPLE
               26.18   / 12 =   3

    ANNUAL SUPERVISION MANMONTHS / 12 = NO. OF SUPERVISORS
            3.40   / 12 =   1

    ANNUAL ADMINISTRATIVE MANMONTHS / 12 = NO. OF ADMINISTRTRS
            3.40   / 12 =   1

    NO. OF DIRECT SUPPORT PEOPLE   3
    NO. OF SUPERVISORS   1
+ NO. OF ADMINISTRATORS   1
    --------------------------------- ----
    NO. OF PEOPLE   5

FACILITY

    DIRECT SUPPORT PEOPLE X REQ. TECHNICAL SPACE/PERSON = REQ. WORKING SPACE
           3   X   275.   =   825.00

    (SUPERVSRS + ADMNSTRTRS) X REQ. SUPERVISORY SPACE/PERSON = ADDITIONAL SPACE
    (1   +   1   ) X   130.   =   260.00

    REQUIRED WORKING SPACE + ADDITIONAL SPACE = TOTAL SPACE
        825.00   +   260.00   = 1085.00

    TOTAL SPACE X COST/SQUARE FOOT = FACILITY COST
      1085.00 X   136.00   =   147560.

    FACILITY COST / EXPECTED SYSTEM LIFE = ANNUAL FACILITY COST
      147560. /   20   =   7378.

UTILITIES

    TOTAL SPACE X COST/SQUARE FOOT = UTILITY COST
      1085.00 X   1.20   =   1302.

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(En) RECEIVER

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981s)
REPRESENTATIVE SYSTEM
YEAR 1981

FURNISHINGS

    TOTAL PERSONS X INITIAL COST/PERSON = INITIAL FURNISHINGS COST
          5   X   680.   =   3400.

    INITIAL FURRNISHINGS COST / EXPECTED SYSTEM LIFE = ANNUAL FURNISHINGS COST
              3400.   /   20   =   170.

MATERIALS AND SUPPLIES

    TOTAL PERSONS X COST/PERSON = MATERIALS & SUPPLIES COST
          5   X   700.   =   3500.

COMPUTERS/TERMINALS

    NO. DIRECT SUPPORT PEOPLE X INITIAL COST/PERSON = INITIAL COMP TERM COST
              3   X   20000.   =   60000.

    INITIAL COMP TERM COST / EXPECTED SYSTEM LIFE = ANNUAL COMP TERM COST
              60000.   /   20   =   3000.

HARDWARE MAINTENANCE

    HARDWARE COST (1981S) X MAINTENANCE RATIO = ANNUAL HARDWARE MAINTENANCE COS
          5571000.   X   0.10   =   557100.

GENERAL SUPPORT EQUIPMENT COST

      FACILITY COST   7378.
      UTILITY COST   1302.
      FURNISHINGS COST   170.
      MATERIALS & SUPPLIES COST   3500.
      COMPUTERS/TERMINALS COST   3000.
    + HARDWARE MAINTENANCE COST   557100.
      --------------------------------- ------------
      GENERAL SUPPORT EQUIPMENT CUST   572450.

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APPENDIX J

(EW) Integrated System

Representative System

APPENDIX J

(EW) INTEGRATED SYSTEM

BREAK DOWN OF ANNUAL COSTS (1981$)
REPRESENTATIVE SYSTEM
YEAR 1981

TOTAL ANNUAL COST   1667721.

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TOTAL LABOR                                            246601.
    DIRECT LABOR                            198256.
        REQUIREMENTS REVIEW    17881.
        DESIGN                 31420.
        DEVELOPMENT            30450.
        INTEGRATION            30250.
        TEST AND EVALUATION    55126.
        DOCUMENTATION          33129.
        REPRODUCTION/INSTALL       0.
        SUPPORT SOFTWARE           0.
    INDIRECT LABOR                           48345.
        SUPERVISION            34028.
        ADMINISTRATION         14317.

TOTAL SUPPORT EQUIPMENT                               1421120.
    DIRECT                                  997902.
        HARDWARE              200000.
        SUPPORT SOFTWARE      200000.
        TEST AIRCRAFT TIME    596852.
        REPRODUCTION            1050.
    GENERAL                                 423218.
        FACILITY              11118.
        UTILITIES              1962.
        FURNISHINGS             238.
        MATERIALS & SUPPLIES   4900.
        COMPUTERS/TERMINALS    5000.
        HARDWARE MAINTENANCE 400000.
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APPENDIX J

(EW) INTEGRATED SYSTEM

DERIVATION OF ANNUAL DIRECT LABOR COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1981

PHASE	REQUIRED MANMONTHS	COST PER MANMONTH	DIRECT LABOR COST
1. REQUIREMENTS REVEIW	5.38	3325.	17881.
2. DESIGN	9.45	3325.	31420.
3. DEVELOPMENT	9.16	3325.	30450.
4. INTEGRATION	9.10	3325.	30250.
5. TEST AND EVALUATION	16.58	3325.	55126.
6. DOCUMENTATION	9.96	3325.	33129.
7. REPRO/INSTALLATION	0.00	3325.	0.
8. SUPPORT SOFTWARE	0.00	3325.	0.
TOTAL	59.63	3325.	198256.

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APPENDIX J

(EX) INTEGRATED SYSTEM

DERIVATION OF ANNUAL INDIRECT LABOR COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1981

SUPERVISION

DIRECT ANNUALIZED ON-SITE MANMONTHS X SUPERVISN RATIO = SUPERVISN MANMONTHS
                59.63   X   0.13   =   7.75

SUPERVISION MANMONTHS X COST/MANMONTH = SUPERVISION COST
        7.75   X   4390.   =   34028.

ADMINISTRATIVE

DIRECT ANNUALIZED ON-SITE MANMONTHS X ADMNSTIVE RATIO = ADMNSTIVE MANMONTHS
                59.63   X   0.13   =   7.75

ADMNSTIVE MANMONTHS X COST/MANMONTH X ADM COMP-FACT = ADMNSTIVE COST
        7.75   X   1847.   X   1.000   =   14317.

TOTAL INDIRECT LABOR

SUPERVISION + ADMINISTRATIVE = INDIRECT LABOR COSTS
   34028.   +   14317.   =   48345.

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APPENDIX J

(EW) INTEGRATED SYSTEM

DERIVATION OF ANNUAL DIRECT SUPPORT EQUIPMENT COSTS (1981$)
REPRESENTATIVE SYSTEM
YEAR 1981

EQUIPMENT

	HARDWARE	SUPPORT SOFTWARE	TOTAL
INITIAL COST (1981$)	4000000.	4000000.	8000000.
COST (1981$)	4000000.	4000000.	8000000.
EXPECTED SYSTEM LIFE	20	20	20
ANNUAL EQUIPMENT COST	200000.	200000.	400000.

TEST AIRCRAFT/TIME

ANNUAL T&E MANMONTHS X 144 = ANNUAL T&E MANHOURS
    16.58   X 144 =   2387.41

ANNUAL T&E MANHOURS X T&E RATIO = TEST AIRCRAFT HOURS
    2387.41   X 0.050   =   119.37

TEST AIRCRAFT HOURS X COST/HOUR = ANNUAL AIRCRAFT/TIME COST
    119.37   X   5000.   =   596852.

REPRODUCTION

NUMBER OF FIELDED SYSTEMS X MED REP-FACT X COST/REPRO = REPRODUCTION COST
    250   X   0.120   X   35.00   =   1050.

REPRODUCTION COST X 12 / BLOCK CHANGE LENGTH = ANNUAL REPRODUCTION COST
    1050.   X 12 /   12   =   1050.

DIRECT SUPPORT EQUIPMENT COSTS

DIRECT HARDWARE COST	200000.
DIRECT SOFTWARE COST	200000.
AIRCRAFT/TIME COST	596852.
+ REPRODUCTION COST	1050.
DIRECT SUPPORT EQUIPMENT COST	997902.

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APPENDIX J

(EW) INTEGRATED SYSTEM

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981s)
REPRESENTATIVE SYSTEM
YEAR 1981

PEOPLE REQUIRED

REQUIRED ANNUAL ON-SITE MANMONTHS / 12 = NO. OF DIRECT SUPPORT PEOPLE
                59.63   / 12 =   5

ANNUAL SUPERVISION MANMONTHS / 12 = NO. OF SUPERVISORS
            7.75   / 12 =   1

ANNUAL ADMINISTRATIVE MANMONTHS / 12 = NO. OF ADMINISTRTRS
              7.75   / 12 =   1

NO. OF DIRECT SUPPORT PEOPLE   5
NO. OF SUPERVISORS   1
+ NO. OF ADMINISTRATORS   1
--------------------------------- ----
NO. OF PEOPLE   7

FACILITY

DIRECT SUPPORT PEOPLE X REQ. TECHNICAL SPACE/PERSON = REQ. WORKING SPACE
            5   X   275.   =   1375.00

(SUPERVSRS + ADMNSTRTRS) X REQ. SUPERVISORY SPACE/PERSON = ADDITIONAL SPACE
(1   +   1   ) X   130.   =   260.00

REQUIRED WORKING SPACE + ADDITIONAL SPACE = TOTAL SPACE
        1375.00   +   260.00   =   1635.00

TOTAL SPACE X COST/SQUARE FOOT = FACILITY COST
   1635.00 X   136.00   =   222360.

FACILITY COST / EXPECTED SYSTEM LIFE = ANNUAL FACILITY COST
   222360.   /   20   =   11118.

UTILITIES

TOTAL SPACE X COST/SQUARE FOOT = UTILITY COST
   1635.00 X   1.20   =   1962.

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APPENDIX J

(EW) INTEGRATED SYSTEM

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1981

FURNISHINGS

```
TOTAL PERSONS X INITIAL COST/PERSON = INITIAL FURNISHINGS COST
     7        X        680.        =           4760.

INITIAL FURRNISHINGS COST / EXPECTED SYSTEM LIFE = ANNUAL FURNISHINGS COST
         4760.              /         20          =           238.
```

MATERIALS AND SUPPLIES

```
TOTAL PERSONS X COST/PERSON = MATERIALS & SUPPLIES COST
     7        X    700.     =            4900.
```

COMPUTERS/TERMINALS

```
NO. DIRECT SUPPORT PEOPLE X INITIAL COST/PERSON = INITIAL COMP TERM COST
          5                X       20000.        =        100000.

INITIAL COMP TERM COST / EXPECTED SYSTEM LIFE = ANNUAL COMP TERM COST
       100000.          /        20           =          5000.
```

HARDWARE MAINTENANCE

```
HARDWARE COST (1981S) X MAINTENANCE RATIO = ANNUAL HARDWARE MAINTENANCE COS
     4000000.          X        0.10       =           400000.
```

GENERAL SUPPORT EQUIPMENT COST

```
    FACILITY COST                   11118.
    UTILITY COST                     1962.
    FURNISHINGS COST                  238.
    MATERIALS & SUPPLIES COST        4900.
    COMPUTERS/TERMINALS COST         5000.
  + HARDWARE MAINTENANCE COST      400000.
    ------------------------------ ----------
    GENERAL SUPPORT EQUIPMENT COST 423218.
```

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APPENDIX J

(OFP) Navigation Fire Control Weapon Delivery

Representative System

APPENDIX J

(OFP) NAVIGATION FIRE CONTROL WEAPON DELIVERY

BREAK DOWN OF ANNUAL COSTS (1981$)
REPPESENTATIVE SYSTEM
YEAR 1981

TOTAL ANNUAL COST   839884.

```
TOTAL LABOR                                              219172.
    DIRECT LABOR                               179228.
        REGUIREMENTS REVIEW       33776.
        DESIGN                    22662.
        DEVELOPMENT               21708.
        INTEGRATION               10211.
        TEST AND EVALUATION       37220.
        DOCUMENTATION             18080.
        REPRODUCTION/INSTALL       5037.
        SUPPORT SOFTWARE          30534.
    INDIRECT LABOR                              39945.
        SUPERVISION               28116.
        ADMINISTRATION            11829.

TOTAL SUPPORT EQUIPMENT                                  620712.
    DIRECT                                     290494.
        HARDWARE                 153500.
        SUPPORT SOFTWARE          46500.
        TEST AIRCRAFT TIME        88394.
        REPRODUCTION               2100.
    GENERAL                                    330218.
        FACILITY                  11118.
        UTILITIES                  1962.
        FURNISHINGS                 238.
        MATERIALS & SUPPLIES       4900.
        COMPUTERS/TERMINALS        5000.
        HARDWARE MAINTENANCE     307000.
```

APPENDIX J

(OFP) NAVIGATION FIRE CONTROL WEAPON DELIVERY

DERIVATION OF ANNUAL DIRECT LABOR COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1981

PHASE	REQUIRED MANMONTHS	COST PER MANMONTH	DIRECT LABOR COST
1. REQUIREMENTS REVEIW	9.28	3638.	33776.
2. DESIGN	6.23	3638.	22662.
3. DEVELOPMENT	5.97	3638.	21708.
4. INTEGRATION	2.81	3638.	10211.
5. TEST AND EVALUATION	10.23	3638.	37220.
6. DOCUMENTATION	4.97	3638.	18080.
7. PEPRO/INSTALLATION	1.38	3638.	5037.
8. SUPPORT SOFTWARE	8.39	3638.	30534.
TOTAL	49.27	3638.	179228.

APPENDIX J

(OFP) NAVIGATION FIRE CONTROL WEAPON DELIVERY

DERIVATION OF ANNUAL INDIRECT LABOR COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1981

SUPERVISION

DIRECT ANNUALIZED ON-SITE MANMONTHS X SUPERVISN RATIO = SUPERVISN MANMONTHS
            49.27   X   0.13   =   6.40

SUPERVISION MANMONTHS X COST/MANMONTH = SUPERVISION COST
        6.40   X   4390.   =   28116.

ADMINISTRATIVE

DIRECT ANNUALIZED ON-SITE MANMONTHS X ADMNSTIVE RATIO = ADMNSTIVE MANMONTHS
            49.27   X   0.13   =   6.40

ADMNSTIVE MANMONTHS X COST/MANMONTH X ADM COMP-FACT = ADMNSTIVE COST
        6.40   X   1847.   X   1.000   =   11829.

TOTAL INDIRECT LABOR

SUPERVISION + ADMINISTRATIVE = INDIRECT LABOR COSTS
   28116.   +   11829.   =   39945.

APPENDIX J

(GFP) NAVIGATION FIRE CONTROL WEAPON DELIVERY

DERIVATION OF ANNUAL DIRECT SUPPORT EQUIPMENT COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1981

EQUIPMENT

	HARDWARE	SUPPORT SOFTWARE	TOTAL
INITIAL COST (1981S)	3070000.	930000.	4000000.
COST (1981S)	3070000.	930000.	4000000.
EXPECTED SYSTEM LIFE	20	20	20
ANNUAL EQUIPMENT COST	153500.	46500.	200000.

TEST AIRCRAFT/TIME

ANNUAL T&E MANMONTHS X 144 = ANNUAL T&E MANHOURS
     10.23   X 144 =   1473.23

ANNUAL T&E MANHOURS X T&E RATIO = TEST AIRCRAFT HOURS
     1473.23   X 0.030   =   44.20

TEST AIRCRAFT HOURS X COST/HOUR = ANNUAL AIRCRAFT/TIME COST
     44.20   X   2000.   =   88394.

REPRODUCTION

NUMBER OF FIELDED SYSTEMS X MED REP-FACT X COST/REPRO = REPRODUCTION COST
          500   X   0.120   X   35.00   =   2100.

REPRODUCTION COST X 12 / BLOCK CHANGE LENGTH = ANNUAL REPRODUCTION COST
     2100.   X 12 /   12   =   2100.

DIRECT SUPPORT EQUIPMENT COSTS

DIRECT HARDWARE COST	153500.
DIRECT SOFTWARE COST	46500.
AIRCRAFT/TIME COST	88394.
+ REPRODUCTION COST	2100.
DIRECT SUPPORT EQUIPMENT COST	290494.

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APPENDIX J

(OFP) NAVIGATION FIRE CONTROL WEAPON DELIVERY

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1981

PEOPLE REQUIRED

    REQUIRED ANNUAL ON-SITE MANMONTHS / 12 = NO. OF DIRECT SUPPORT PEOPLE
                  49.27   / 12 =   5

    ANNUAL SUPERVISION MANMONTHS / 12 = NO. OF SUPERVISORS
               6.40   / 12 =   1

    ANNUAL ADMINISTRATIVE MANMONTHS / 12 = NO. OF ADMINISTRTRS
                  6.40   / 12 =   1

    NO. OF DIRECT SUPPORT PEOPLE   5
    NO. OF SUPERVISORS   1
  + NO. OF ADMINISTRATORS   1
    ------------------------------------ ----
    NO. OF PEOPLE   7

FACILITY

    DIRECT SUPPORT PEOPLE X REQ. TECHNICAL SPACE/PERSON = REQ. WORKING SPACE
               5   X   275.   =   1375.00

    (SUPERVSRS + ADMNSTRTRS) X REQ. SUPERVISORY SPACE/PERSON = ADDITIONAL SPACE
    (1   +   1   ) X   130.   =   260.00

    REQUIRED WORKING SPACE + ADDITIONAL SPACE = TOTAL SPACE
            1375.00   +   260.00   =   1635.00

    TOTAL SPACE X COST/SQUARE FOOT = FACILITY COST
      1635.00   X   136.00   =   222360.

    FACILITY COST / EXPECTED SYSTEM LIFE = ANNUAL FACILITY COST
       222360.   /   20   =   11118.

UTILITIES

    TOTAL SPACE X COST/SQUARE FOOT = UTILITY COST
      1635.00   X   1.20   =   1962.

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APPENDIX J

(OFP) NAVIGATION FIRE CONTROL WEAPON DELIVERY

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981$)
REPRESENTATIVE SYSTEM
YEAR 1981

FURNISHINGS
```
------------
```

```
    TOTAL PERSONS X INITIAL COST/PERSON = INITIAL FURNISHINGS COST
         7         X       680.         =          4760.

    INITIAL FURNISHINGS COST / EXPECTED SYSTEM LIFE = ANNUAL FURNISHINGS COST
             4760.            /           20         =          238.
```

MATERIALS AND SUPPLIES
```
-----------------------
```

```
    TOTAL PERSONS X COST/PERSON = MATERIALS & SUPPLIES COST
         7        X    700.     =          4900.
```

COMPUTERS/TERMINALS
```
---------------------
```

```
    NO. DIRECT SUPPORT PEOPLE X INITIAL COST/PERSON = INITIAL COMP TERM COST
               5              X      20000.         =        100000.

    INITIAL COMP TERM COST / EXPECTED SYSTEM LIFE = ANNUAL COMP TERM COST
            100000.         /          20          =         5000.
```

HARDWARE MAINTENANCE
```
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```

```
    HARDWARE COST (1981$) X MAINTENANCE RATIO = ANNUAL HARDWARE MAINTENANCE COS
          3070000.        X      0.10         =         307000.
```

GENERAL SUPPORT EQUIPMENT COST
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```

```
      FACILITY COST                     11118.
      UTILITY COST                       1962.
      FURNISHINGS COST                    238.
      MATERIALS & SUPPLIES COST          4900.
      COMPUTERS/TERMINALS COST           5000.
   +  HARDWARE MAINTENANCE COST        307000.
      ------------------------------   --------
      GENERAL SUPPORT EQUIPMENT COST   330218.
```

APPENDIX J

(CE) Command and Control

Representative System

APPENDIX J

(CE) COMMAND AND CONTROL

BREAK DOWN OF ANNUAL COSTS (1981s)
REPRESENTATIVE SYSTEM
YEAR 1991

TOTAL ANNUAL COST   912764.

TOTAL LABOR			129518.
DIRECT LABOR		104126.	
REQUIREMENTS REVIEW	3945.		
DESIGN	12554.		
DEVELOPMENT	33043.		
INTEGRATION	5104.		
TEST AND EVALUATION	7839.		
DOCUMENTATION	4572.		
REPRODUCTION/INSTALL	10990.		
SUPPORT SOFTWARE	26079.		
INDIRECT LABOR		25391.	
SUPERVISION	17872.		
ADMINISTRATION	7519.		
TOTAL SUPPORT EQUIPMENT			783246.
DIRECT		463796.	
HARDWARE	152050.		
SUPPORT SOFTWARE	197950.		
TEST AIRCRAFT TIME	71296.		
REPRODUCTION	42500.		
GENERAL		319450.	
FACILITY	7378.		
UTILITIES	1302.		
FURNISHINGS	170.		
MATERIALS & SUPPLIES	3500.		
COMPUTERS/TERMINALS	3000.		
HARDWARE MAINTENANCE	304100.		

APPENDIX J

(CE) COMMAND AND CONTROL

DERIVATION OF ANNUAL DIRECT LABOR COSTS (1981$)
REPRESENTATIVE SYSTEM
YEAR 1981

PHASE	REQUIRED MANMONTHS	COST PER MANMONTH	DIRECT LABOR COST
1. REQUIREMENTS REVEIW	1.19	3325.	3945.
2. DESIGN	3.78	3325.	12554.
3. DEVELOPMENT	9.94	3325.	33043.
4. INTEGRATION	1.54	3325.	5104.
5. TEST AND EVALUATION	2.36	3325.	7839.
6. DOCUMENTATION	1.37	3325.	4572.
7. REPRO/INSTALLATION	3.31	3325.	10990.
8. SUPPORT SOFTWARE	7.84	3325.	26079.
TOTAL	31.32	3325.	104126.

APPENDIX J

(CE) COMMAND AND CONTROL

DERIVATION OF ANNUAL INDIRECT LABOR COSTS (1981S)
REPRESENTATIVE SYSTEM
YEAR 1981

SUPERVISION

DIRECT ANNUALIZED ON-SITE MANMONTHS X SUPERVISN RATIO = SUPERVISN MANMONTHS
$$31.32 \quad \times \quad 0.13 \quad = \quad 4.07$$

SUPERVISION MANMONTHS X COST/MANMONTH = SUPERVISION COST
$$4.07 \quad \times \quad 4390. \quad = \quad 17872.$$

ADMINISTRATIVE

DIRECT ANNUALIZED ON-SITE MANMONTHS X ADMNSTIVE RATIO = ADMNSTIVE MANMONTHS
$$31.32 \quad \times \quad 0.13 \quad = \quad 4.07$$

ADMNSTIVE MANMONTHS X COST/MANMONTH X ADM COMP-FACT = ADMNSTIVE COST
$$4.07 \quad \times \quad 1847. \quad \times \quad 1.000 \quad = \quad 7519.$$

TOTAL INDIRECT LABOR

SUPERVISION + ADMINISTRATIVE = INDIRECT LABOR COSTS
$$17872. \quad + \quad 7519. \quad = \quad 25391.$$

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APPENDIX J

(C²) COMMAND AND CONTROL

DERIVATION OF ANNUAL DIRECT SUPPORT EQUIPMENT COSTS (1981$)
REPRESENTATIVE SYSTEM
YEAR 1981

EQUIPMENT

	HARDWARE	SUPPORT SOFTWARE	TOTAL
INITIAL COST (1981$)	3041000.	3959000.	7000000.
COST (1981$)	3041000.	3959000.	7000000.
EXPECTED SYSTEM LIFE	20	20	20
ANNUAL EQUIPMENT COST	152050.	197950.	350000.

TEST AIRCRAFT/TIME

ANNUAL T&E MANMONTHS X 144 = ANNUAL T&E MANHOURS
         2.36   X 144 =   339.50

ANNUAL T&E MANHOURS X T&E RATIO = TEST AIRCRAFT HOURS
       339.50   X 0.035   =   11.88

TEST AIRCRAFT HOURS X COST/HOUR = ANNUAL AIRCRAFT/TIME COST
       11.88   X   6000. =   71296.

REPRODUCTION

NUMBER OF FIELDED SYSTEMS X MED REP-FACT X COST/REPRO = REPRODUCTION COST
           100   X   25.000   X 17.00   =   42500.

REPRODUCTION COST X 12 / BLOCK CHANGE LENGTH = ANNUAL REPRODUCTION COST
       42500.   X 12 /   12   =   42500.

DIRECT SUPPORT EQUIPMENT COSTS

DIRECT HARDWARE COST	152050.
DIRECT SOFTWARE COST	197950.
AIRCRAFT/TIME COST	71296.
✦ REPRODUCTION COST	42500.
DIRECT SUPPORT EQUIPMENT COST	463796.

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APPENDIX J

(CE) COMMAND AND CONTROL

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981s)
REPRESENTATIVE SYSTEM
YEAR 1961

PEOPLE REQUIRED
————————————————

REQUIRED ANNUAL ON-SITE MANMONTHS / 12 = NO. OF DIRECT SUPPORT PEOPLE
            31.32   / 12 =   3

ANNUAL SUPERVISION MANMONTHS / 12 = NO. OF SUPERVISORS
            4.07   / 12 =   1

ANNUAL ADMINISTRATIVE MANMONTHS / 12 = NO. OF ADMINISTRTRS
            4.07   / 12 =   1

NO. OF DIRECT SUPPORT PEOPLE   3
NO. OF SUPERVISORS   1
+ NO. OF ADMINISTRATORS   1
———————————————————————————————— ————
NO. OF PEOPLE   5

FACILITY
————————

DIRECT SUPPORT PEOPLE X REQ. TECHNICAL SPACE/PERSON = REQ. WORKING SPACE
         3   X   275.   =   825.00

(SUPERVSRS + ADMNSTRTRS) X REQ. SUPERVISORY SPACE/PERSON = ADDITIONAL SPACE
(1   +   1   ) X   130.   =   260.00

REQUIRED WORKING SPACE + ADDITIONAL SPACE = TOTAL SPACE
         825.00   +   260.00   =   1085.00

TOTAL SPACE X COST/SQUARE FOOT = FACILITY COST
   1085.00 X   136.00   =   147560.

FACILITY COST / EXPECTED SYSTEM LIFE = ANNUAL FACILITY COST
   147560.   /   20   =   7378.

UTILITIES
——————————

TOTAL SPACE X COST/SQUARE FOOT = UTILITY COST
   1085.00 X   1.20   =   1302.

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(CE) COMMAND AND CONTROL

DERIVATION OF ANNUAL GENERAL SUPPORT EQUIPMENT COSTS (1981s)
REPRESENTATIVE SYSTEM
YEAR 1981

FURNISHINGS

TOTAL PERSONS X INITIAL COST/PERSON = INITIAL FURNISHINGS COST
     5   X   680.   =   3400.

INITIAL FURNISHINGS COST / EXPECTED SYSTEM LIFE = ANNUAL FURNISHINGS COST
         3400.   /   20   =   170.

MATERIALS AND SUPPLIES

TOTAL PERSONS X COST/PERSON = MATERIALS & SUPPLIES COST
     5   X   700.   =   3500.

COMPUTERS/TERMINALS

NO. DIRECT SUPPORT PEOPLE X INITIAL COST/PERSON = INITIAL COMP TERM COST
          3   X   20000.   =   60000.

INITIAL COMP TERM COST / EXPECTED SYSTEM LIFE = ANNUAL COMP TERM COST
         60000.   /   20   =   3000.

HARDWARE MAINTENANCE

HARDWARE COST (1981s) X MAINTENANCE RATIO = ANNUAL HARDWARE MAINTENANCE COST
       3041000.   X   0.10   =   304100.

GENERAL SUPPORT EQUIPMENT COST

```
    FACILITY COST                    7378.
    UTILITY COST                     1302.
    FURNISHINGS COST                  170.
    MATERIALS & SUPPLIES COST        3500.
    COMPUTERS/TERMINALS COST          300.
  + HARDWARE MAINTENANCE COST      304100.
    ---------------------------------------
    GENERAL SUPPORT EQUIPMENT COST  319450.
```

APPENDIX
K

APPENDIX K

DERIVATION OF ALLOCATION FACTORS

System	Requirements Review	Design	Development	Integration	T&E	Documentation	Reproduction/ Installation
F-111F	9	14	14	19	24	14	6
FB-111A	9	27	12	6	24	20	2
F16-FCC	24	20	16	9	18	12	1
ALQ-155	8	12	13	25	29	13	0
ALR-62	4	25	28	17	11	11	4
ALQ-131	7	12	11	11	29	25	5
APR-38	9	16	15	16	29	15	0
E-3A	5	19	49	8	9	6	4
A-7	20	7	15	7	27	12	2
Selected Average	11	17	21	13	21	14	3

END

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